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EGG PASTEURIZATION MANUAL

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Prepared in the Poultry Laboratory of the

Western Utilization Research and Development Division

Agricultural Research Service

UNITED STATES DEPARTMENT OF AGRICULTURE

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Statement of Need

The Institute of American Poultry Industries' Research Council recognized a real need on the part of processors of egg products for fundamental information on the pasteurization process, the composition of egg products, and the factors affected by pasteurization. Therefore, the Council recommended that a manual on the pasteurization of egg products should be developed. They recommended that such a manual should include "the basic background, including physical and chemical properties and microbiological factors involved in the raw and manufactured products; types and uses for products with added ingredients; packaging; labeling; sanitation; facilities and equipment; plant layout; and operating guidelines."

The Institute's Egg Products Committee also requested such a manual as an aid in training new personnel and in coordinating regulations of Health, Education, and Welfare's Public Health Service; State and local governments; and commercial users.

In accord with these recommendations, USDA's Agricultural Research Service and Consumer and Marketing Service were requested to develop such a manual. Leadership in its development was assigned to the Poultry Laboratory of USDA's Western Utilization Research and Development Division.

This manual will be of great benefit to the processors of egg products, as well as users of egg products, and should aid immeasurably in eliminating salmonellae as contaminants of egg products. It will contribute to continued progress within the egg products industry.

Harold M. Williams, President

Institute of American Poultry Industries

Statement of Cooperation

The manual was prepared in the Poultry Laboratory of the Western Utilization Research and Development Division, Agricultural Research Service, USDA, with the advice of the Poultry Division, Consumer and Marketing Service, USDA, who reviewed it in depth. The contributors were:

Hans Lineweaver, Chief, Poultry Laboratory
Helen H. Palmer, Food Technologist, Poultry Laboratory
G. W. Putnam, General Engineer, Poultry Laboratory
J. A. Garibaldi, Research Chemist, Poultry Laboratory
V. F. Kaufman, Chemical Engineer, Engineering and Development Laboratory

Major reviewers from the Grading Branch of the Poultry Division of Consumer and Marketing Service include:

B. W. Kempers, Chief
E. I. Rosenquist, Head, Egg Products Section
R. T. Carey, Food Technologist

For many helpful comments and suggestions, the contributors thank staff members of the Public Health Service, U. S. Department of Health, Education, and Welfare; Seymour Foods Div., Norris Grain Co.; Armour and Co.; Henningsen Foods, Inc.; Standard Brands; and various equipment companies.

The contributors have attempted to explain what various treatments do and why they are necessary. The information given is believed to be reliable. However, no liability for damages from any cause is assumed nor are assurances given regarding freedom from patents. Reference to a company or product name does not imply approval or recommendation of the product by the U.S. Department of Agriculture to the exclusion of others that may be suitable.

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Egg Pasteurization Manual

INTRODUCTION

The purpose of this manual is to help the egg processor to meet pasteurization regulations applicable to his operation and to improve the quality of his products. Information is included on the composition of eggs, on their physical and chemical properties, on properties of microorganisms, on pertinent sanitation principles, on methods of pasteurization, on layout, installing, operating and sanitizing of equipment, and on types of egg products and their uses, including those with added ingredients.

Eggs are valued for their nutritional quality, flavor, color, and functional properties that contribute to the structure, consistency, and texture of foods. Egg proteins contain all of the essential amino acids in readily digestible form. Eggs are good sources of essential fats, minerals, and vitamins A, D, and B complex, all needed for the growth and maintenance of healthy body tissues. The bland flavor of eggs makes them useful when served with minimal seasoning or when combined with other ingredients in a wide variety of products. The yellow color of egg yolk is essential for the characteristic appearance of noodles, salad dressing, and many baked products.

Although the contents of freshly laid shell eggs are generally sterile, microoganisms, some of which are health hazards, can penetrate the shell and multiply under poor holding conditions. The pathogens of chief concern are the numerous micoorganisms belonging to the genus Salmonella. If ingested in sufficient number, these microorganisms can cause illness. Generally, the illness is a gastroenteritis commonly spoken of as food poisoning. However, the illness can vary markedly in severity. These organisms are readily destroyed by cooking. Hazards exist in the consumption of raw and partly cooked food and also in possible cross-contamination if any food containing salmonellae is brought into the kitchen or a food preparation establishment. It has been well established that pasteurization and good handling all the way from producer to user assure that commercially processed egg products are free of the salmonella health hazard.

Pasteurization causes no significant change in nutritive value, flavor, or color of egg. However, the functional properties of eggs (the ability to foam, to thicken, to bind, and to emulsify) may be affected in varying degree by heating. The minimum heat required to destroy salmonellae is, therefore, used in pasteurization of egg products. There is a fairly small margin between a pasteurization treatment that provides adequate kill of salmonellae and a treatment that seriously damages egg products properties. This means that considerable care must be exercised by the processor. The situation contrasts somewhat with milk pasteurization, because milk withstands higher temperatures than egg without serious damage to its properties. It is obvious, but worth noting, that pasteurization is wasted if recontamination occurs. Comments about factors that may lead to recontamination and ways to minimize this hazard are contained in Part IV.

PART I. CHARACTERISTICS OF EGGS WITH SPECIAL REFERENCE TO PROPERTIES AFFECTED BY PASTEURIZATION TREATMENTS

Gross Composition of Eggs

On the average, eggs consist of about 11 percent shell, 58 percent white, and 31 percent yolk. The egg contents consist of about 65 percent white and 35 percent yolk. However, when eggs are separated under commercial conditions, 12 to 15 percent of the white goes with the yolk fraction to give yields of 55 to 57 per percent white and 43 to 45 percent yolk. The composition of eggs as reported in *Agriculture Handbook No. 8 (64)*[1/] is given in table 1.

The composition of eggs varies somewhat with age of layer, with egg size, and treatment between time-of-lay and time-of-breaking. Moisture loss and water transfer from white to yolk, which occur during storage, alter the percent solids and yield of white and yolk. The solids content of whole egg from eggs that experienced essentially no moisture loss was recently reported to range from 24.0 to 25.2 percent (*30*). A recent trend has been toward use of a higher quality egg for breaking. Such eggs have a lower solids content than older eggs. To reflect this, regulations for products labeled "whites and yolks" have been changed so that declaration of solids content is required only if the solids are below 24.7 percent instead of the former 25.5 percent.

The following comments concern pure yolk and white rather than the commercial yolk that contains about 15 percent white, unless specifically mentioned.

Table 1. — *Composition of raw liquid egg products (units per 100 g. or in percent)*

Item	Whole liquid	Whites	Yolks[1/]	Yolks (commercially separated)
Water, pct.	[2/]73.7	[2/]87.6	51.1	55.5
Protein, pct.	12.9	10.9	16.0	15.4
Fat, pct.	11.5	Trace	30.6	26.9
Carbohydrate[3/], pct.	1.1	1.1	1.0	1.0
Free Carbohydrate[4/], pct.	0.3	0.4	0.2	0.2
Ash, pct.	1.0	0.7	1.7	1.6
Calcium, mg.	54	9	141	125
Phosphorus, mg.	205	15	569	502
Iron, mg.	2.3	0.1	5.5	4.9
Sodium, mg.	122	146	52	63
Potassium, mg.	129	139	98	100
Magnesium, mg.	11	9	16	
Vit. A value, I. U.	1,800	0	3,400	2,900
Thiamine, mg.	0.11	Trace	0.22	0.20
Riboflavin, mg.	0.30	0.27	0.44	0.42
Niacin, mg.	0.1	0.1	0.1	0.1
Food energy, calories	163	51	348	312
Cholesterol, mg	550	0	1,500	1,280

1/ Yolks separated under laboratory conditions include only a small porportion of white; commercially separated yolks include considerable white.
2/ Higher values (75.5 percent for whole eggs and 88.5 percent for egg whites) are characteristic of eggs that have not lost moisture (see text).
3/ Unpublished results.
4/ Source, Mitchell (*43*).

1/ Italic numbers in parentheses refer to literature cited at end of manual.

Yolk solids remain fairly constant at 52 to 53 percent regardless of age of layer and egg size. The percentage of yolk in eggs tends to increase with age of layer, ranging from 32 percent for eggs weighing 24 to 26 ounces per dozen from hens 10 months old to 34 percent from hens 19.5 months of age. For any age of layer, the yield of yolk is less when the egg is larger. However the age-of-layer effect dominates, so that the yield (weight basis) of yolk is greater from eggs laid by older hens. Kline *et al.* (*30*) estimated that the yield of commercial yolk (43 percent solids) per 30-dozen case (unsized eggs) will be 15 to 20 percent higher from 20-month-old layers than the yield from 8-month-old layers. About half of this increase is due to the greater weight of 30 dozen eggs from old layers and half from the greater yolk content per pound of egg. Both percentage of egg content that is white and the solids content of white tend to decrease with age of layer. For 24-to-26-ounce eggs, the solids content of white was 11.4 and 10.5 percent, respectively, for eggs from 10- and 19.5-month-old layers. However, randomly selected eggs had a high of 12.5 percent white solids at 8 months and a low of 10.9 percent at 20 months. Performance of eggs in products is not affected by the usual range of variations in composition except that a 3 to 4 percent lower angel food cake volume was found for whites with lowest solids. Obviously, there is no reason to discriminate against eggs from old layers. On the contrary, the efficiency resulting from breaking large eggs, the value of yolk, and the decrease in percentage of shell favors eggs from old layers.

Types of Egg Products and Production by Classes

Standards of identity have been published in the Federal Register (*63*) for whole egg, egg white, and egg yolk in liquid, frozen, and dried forms. These standards include sections relating specifically to pasteurization. They also include provisions for inclusion of monosodium phosphate in frozen whole eggs to preserve color and sodium silicoaluminate in dried whole egg and yolk as an anticaking ingredient. Three procedures are described for the optional removal of glucose to improve shelf life of dried egg white. They are an enzyme procedure, a controlled fermentation, and a bacterial procedure.

Egg products are available in 50 or more types other than those for which standards of identity exist. In the year 1967, production of liquid eggs in the United States totaled 801.7 million pounds in the following classes (*61*, p. 428):

Class of product	*Million pounds*
Whole	239.7
Mixed emulsions	161.5
Egg white	236.0
Plain yolk	67.8
Other yolk	164.5

Of the liquid eggs produced in 1967 in the United States, 434.9 million pounds were stored in frozen form for future use; 307.3 million pounds were dried; and 59.5 million pounds were used in liquid form. Ten percent sugar or salt is commonly added to yolks that are to be frozen to prevent gelation during storage. The choice depends upon the intended use. Other whole-egg and yolk products include salt and carbohydrates such as corn syrup. The products typically contain 60 to 70 percent whole eggs, 30 to 40 percent yolks and 5 percent carbohydrate solids. The corn syrup and usually some salt are added to control gelation during freezing.

Properties of Egg Products

Chemical and Antimicrobial Properties. In the development of satisfactory pasteurization procedures for egg white, use was made of our knowledge of the properties of its various components. The pH of white from a freshly laid egg is about 7.6. Unless prevented by oiling or other means, shell eggs lose carbon dioxide rapidly and pH rises. The pH will reach 9 or higher in 1 to 3 days, depending on temperature. Therefore, the pH of commercially broken egg is nearly always in the region of 8.9 to 9.1. Proteins comprise 92 percent of the egg-white solids; the remaining 8 percent is about half salt and half sugar. The unique properties of egg white are primarily dependent on its specific proteins. The conditions suitable for pasteurization are limited by the sensitivity of these proteins to heat under various conditions of acidity (pH), metal addition, and other additives such as whipping aids. A detailed review of the chemical composition of eggs has been published recently (*51*).

Egg white at pH 9 tends to change in viscosity when heated at 134° to 135° F. and coagulates rapidly at 140°. The temperature at which damage occurs is higher for sugared and salted products. The proteins of egg white differ in their coagulation rates at various pH values, in the presence of additives, and in the presence of each other. They also have unique chemical and antimicrobial properties. The protein composition of egg white and the heat stability of the isolated proteins to temperatures of 140° to 150° are given below.

Egg white consists of seven main proteins:	*Percent of total egg white solids:*	*Heat stability of isolated proteins:*
Ovomucin	1.5	
Globulins (two)	7	Very stable.
Lysozyme	3.5	
Ovalbumin	58	Unstable at pH 9;
Ovomucoid	10	stability much greater at pH 7.
Conalbumin	12	Very unstable.
Conalbumin - Fe_2[1/]		Metal complexes are
Conalbumin - Al_2		much more stable than conalbumin.

[1/] This is the form of conalbumin that exists in liquid whole egg because of iron provided by the yolk.

Ovalbumin and ovomucoid are more stable when heated at pH 7 than at pH 9; a metal complex with conalbumin is more stable than is conalbumin alone. Recent research (*14, 19*) shows that mixtures of ovalbumin and lysozyme and of ovomucin and lysozyme are less stable when heated together, as in egg white, than in isolated condition. They interact and become denatured at a much lower temperature than they do when heated separately (see tabular matter below).

Ovalbumin	Interacts with lysozyme. The part that interacts is denatured at a lower temperature than free ovalbumin.
Ovomucin	Interacts with lysozyme and is denatured fairly rapidly at 140°. The presence of denatured material in egg white tends to decrease the whipping rate.
Lysozyme	(a) Destroyed rapidly at pH 9 and 140° by interaction with ovalbumin. (b) Rate of destruction very low at pH 7. Interacts with ovomucin at pH 7 and 140°.

In addition to their variable reaction to heat, the proteins differ in other respects. The ovomucin, ovalbumin, and globulin are important in foam formation and stability; the ovalbumin and other proteins provide structure to baked products by coagulating during heating. Ovalbumin contains most, if not all, of the reactive sulfhydryl groups of egg white; conalbumin binds the enzyme trypsin; lysozyme complexes with ovalbumin and ovomucin and exhibits antimicrobial activity by its ability to lyse microorganisms; avidin inhibits the growth of microorganisms through its ability to bind biotin; ovomucin, the least soluble and most viscous of the egg white proteins, inhibits the agglutinative reaction between red blood cells and heated influenza virus. Loss of the chemical or antimicrobial properties of a protein is often used as an indication that it has been damaged (as by heat treatment in pasteurization), and the extent of the damage can often be assessed by the extent of loss of a particular activity.

The pH of yolk of freshly laid eggs is approximately 6.0; pH increases to about 6.8 after long storage of shell eggs. In fresh yolk the specific gravity is almost that of the white, 1.035; during storage, water from the white diffuses across the yolk membrane into the yolk. The egg yolk solids contain 65 to 70 percent fats, comprising triglycerides (65 percent), the phospholipids lecithin and cephalin (30 percent), cholesterol (4 percent), and traces of carotenoid and vitamins. The egg yolk proteins consist of lipoproteins, phosphoproteins, and livetins. The lipoproteins comprise phosphoproteins combined with phospholipids and possibly with triglycerides. Lipoproteins are responsible for the gelation of yolk and whole egg during frozen storage. The emulsifying ability of egg yolk is primarily due to lecithoproteins (lipoproteins containing the phospholipid lecithin). The phosphoprotein, phosvitin, contains no lipid but contains about two-thirds of the total phosphorus of the egg yolk. Livetins are water-soluble proteins in yolk. The presence of the enzymes tributyrinase, peptidase, catalase, amylase, and phosphatidase and the absence of oxidative enzymes have been demonstrated in yolk (*37*). Sugars and salt raise the temperature of coagulation of both yolk and white.

Functional Properties. Eggs contribute to the volume, structure, texture, and keeping quality of baked products. The coagulation of egg proteins during heating brings thickening of custards and pie fillings and the binding of pieces of food together as in loaves or croquettes. When eggs are whipped the proteins form elastic films and incorporate air that provides the leavening and volume needed in such products as angel food cakes, souffles, sponge cakes, and meringues. The foam structure of these products is made rigid by coagulation of the protein during baking. The elasticity of egg protein films is also important in popovers and cream puffs; the protein films stretch when steam is produced during baking and later coagulate to form the framework of the product. Lipoproteins of the yolk are good emulsifying agents. They make it possible to disperse the oil in the other ingredients and thereby contribute to the consistency of mayonnaise and salad dressing and the structure of cream puff shells.

Whole eggs are used in sponge and layer cakes, bread, and rolls. Yolks are used in mayonnaise and salad dressing, sweet goods, doughnuts, and cakes in which more yellow color is desired. Whites are used in angel food cakes, meringue toppings, puff pastry, white pound cakes, layer cakes, cupcakes, certain candies, and a number of premixed products.

The extent to which the *functional properties* are *affected by pasteurization* or other processing is determined by testing the performance of the eggs under conditions in which damage is readily observed. Damage to egg white is most apparent in changes in the beating rate of the egg white, in the amount of air that is incorporated during beating (specific gravity), in the stability of the foam, and in the volume and texture of angel food cake. Damage to the foaming and coagulating properties of whole egg and egg yolk is evaluated in similar tests using sponge cake as the final product. Damage to the coagulating properties of whole egg or yolk is indicated by measurement of the stiffness of custards. Damage to the emulsifying function of yolk and whole egg is evaluated by the stiffness and stability of mayonnaise and salad dressing and the volume and structure of cream puff shells.

Physical Properties of Commercial Egg Products. The average *density* of whole egg, white, and yolk is commonly given as 1.035 at room temperature (*57*). The density of 10 percent salted yolk or whole egg may be approximated by allowing for the same change that occurs when 10 percent salt is added to water. This is slightly over 0.07, giving a density of 1.105. If the same procedure is used for 10 percent sugared yolk or whole egg and a commercial blend containing 32 to 33 percent solids, values of 1.073 and 1.050 are obtained. A limited number of laboratory runs have given slightly lower figures for the first two products and so the values 1.10 and 1.07 have been used in tables 2 and 3.

A minor decrease in density occurs with temperature increase. If it is assumed that the change in egg products is the same as for water, the decrease in density is about 1.5 percent on heating from 70° F. to a pasteurization temperature of 140°.

An important factor affecting apparent density during pasteurizing operations is the amount of entrained gas bubbles in the product. Mixing, pumping, dissolved gas evolution, gas generated by chemical action, and possibly other sources may cause sufficient gas bubbles to be present so that the density of various products will be reduced 10 percent or more from the foregoing values.

Heat content values, which define the requirements for heating, cooling, and freezing of egg products, were approximated by the use of the following formulae.

Table 2 — *Density of commercial egg products*

Item	Water	Whites, yolks, whole eggs	Blend 32 to 33 percent solids	10 percent sugared yolks or whole eggs	10 percent salted yolks or whole eggs
Density	1.00	1.035	1.05	1.07	1.10
Pounds per cubic foot	62.4	64.6	65.5	67.0	68.6
Pounds per gallon	8.34	8.63	8.76	8.92	9.17

Table 3 — *Amount of products contained in various sized holding tubes at room temperature*

Tube dimensions				Pounds of product per foot of tube				
Outside diam. in.	Thickness[1] gage	Inside diam. in.	Vol.[2] cu. ft./ft. of length	Water	Whites, yolks, whole eggs	32 to 33 percent blend	10 percent sugared products	10 percent salted products
1	18	0.902	0.00442	0.276	0.286	0.290	0.296	0.304
1.5	18	1.402	0.0107	0.668	0.691	0.701	0.717	0.735
2	16	1.870	0.0191	1.19	1.23	1.25	1.28	1.31
2.5	16	2.370	0.0306	1.91	1.98	2.01	2.05	2.10
3	16	2.870	0.0449	2.80	2.90	2.94	3.01	3.08

[1] Wall thickness may be different from that used in this table.
[2] The inside cross-section area of the tubes in square feet is the same as the volume in cubic feet per foot of tube length.

Specific heat above freezing = (percent water + 0.5 × percent solids) /100.

Specific heat of frozen egg = 0.5.

Latent heat of freezing (B.t.u./lb.) = (percent water/100) (144 − 0.5(32 − freezing point)).

This last formula assumes that all water in the product becomes ice by the freezing of product. This is approximately true only when the product is cooled considerably (10° to 20°) below the freezing point *(59)*. The latent heat values in table 4 therefore provide the maximum refrigeration requirements for freezing.

The literature contains numerous articles giving some information on the *viscosity* of egg products. However, no information has been found that is of appreciable aid in calculating the flow characteristics during pasteurization.

The following viscosity-temperature curves for egg products were developed from determinations on approximately 150 samples taken in commercial plants. The samples were taken directly from the pasteurizing lines and included both raw and pasteurized products that had never been frozen. The viscosities were run immediately with a Brookfield viscometer (Model LVF with an adapter for low viscosity materials). The temperatures of most of the samples were at the high and low end of the range, with very few intermediate values. The logarithms of the values were plotted against the reciprocal of the absolute temperature and a straight line drawn as predicted from theory. These straight-line values were used to construct the curves of figure 1. For samples from different lots of the same type of product, viscosities ranged as much as 50 percent above and 40 percent below the values of each shown on these curves, with 20 percent variation common. The viscosity of each product may vary with degree of mixing and homogenization, the solids content, the pH, and the pasteurization treatment. Considerable information is needed to provide a thorough understanding of the quantitative effects of these and other factors on the viscosity of egg products. However, the viscosity of unfrozen egg products does not change greatly with changes in shear rate.

The *flow of egg products* in tubes may be laminar, turbulent, or intermediate between these two types of flow. In laminar flow the lines are maintained downstream and the material in each line of flow retains its identity. The lines of flow are commonly but not necessarily straight, parallel, and steady. Laminar flow in long straight pipes can be considered as concentric cylinders of fluid, with those closer to the center traveling at higher velocities.

In this type of flow there is no mixing action vertical to the direction of flow. In turbulent flow the lines are broken, and there is continuous mixing over the entire cross-section of the flow. If fully turbulent flow is maintained, all material is held in the tubes for nearly the same time. If straight-line laminar flow occurs, the material at the center of the tube flows twice as fast as the average and would be held at the pasteurizing temperature only one-half as long.

A dimensionless term, called the Reynolds number, is commonly used in studying fluid flow. It relates the effects of tube diameter, velocity of flow, fluid density, and viscosity to type of flow. From the values of these factors found in egg pasteurizers one might anticipate that completely laminar flow would commonly occur. However, in addition to these factors there are others that affect the type of flow that occurs in the tube assemblies that are used for holding in egg pasteurizers. These include the effects of the turns at each end of the straight runs of tubing and the irregularities of the inside surfaces

Table 4 — *Heat content of egg products*

Item	Percent solids	Freezing point, °F	Specific heat[1] Above freezing	Specific heat[1] Below freezing	Latent heat of freezing B.t.u./lb.[2]
Water	0	32	1.00	0.5	144
Whole eggs	25	31	0.88	0.5	108
Whites	12	31	0.94	0.5	127
Yolks	44	31	0.78	0.5	81
Sugared yolks	50	25	0.75	0.5	72
Salted yolks	50	1	0.75	0.5	64

[1] B.t.u./lb./°F. or calories/gm./°C.

[2] To convert to calories per gm. muitiply values by O.555. These data together with the specific heat values can be used to calculate the B.t.u. required to lower (or raise) the temperature of eggs including the freezing step. For example, the B.t.u. that must be removed to lower the temperature of 30 lb. of whole eggs from 40° F. to 0° are obtained as follows: $30 \times 0.88 \times (40\text{-}31) + (30 \times 108) + (30 \times 0.5 \times 31) = 3{,}943$ B.t.u.

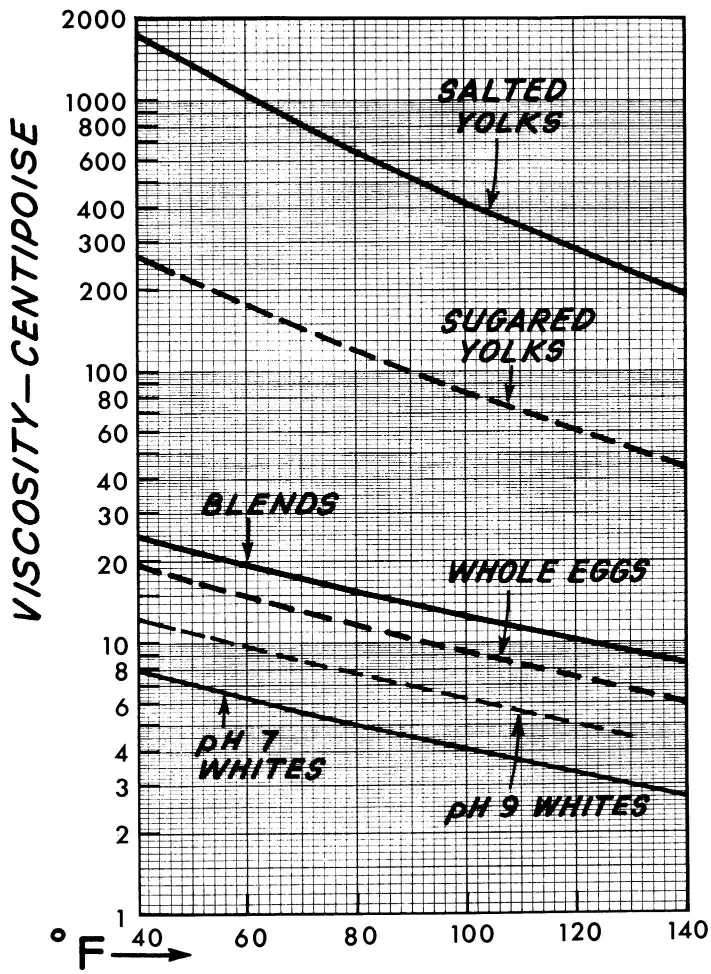

Figure 1. — The viscosity of several commercial egg products at 40° to 140°F. (The viscosity of plain yolks is similar to that of sugared yolks.)

caused by gaskets commonly used in the fittings on the turns. Experimental observations by Kaufman, Ijichi, and Putnam *(28)* indicate that these factors cause a mixed flow that is not reflected in the calculated Reynolds number. As a result of this situation the minimum retention time of the fastest material through the holding tubes can be determined only by experimental means.

Over 50 measurements of minimum residence times have been made in seven processing plants. Although additional studies are needed, the results indicate that in ordinary commercial practice the fastest moving particles pass through the holding tube in about 74 percent of the time for the average particle in the case of whole egg and whites and in about 67 percent of the time for high solids blends and sugared and salted yolks. Instead of measuring residence time for the fastest moving particle it is acceptable to calculate holding time for the fastest-moving particle from the average residence time by assuming that the product is in fully developed laminar flow. The corresponding residence time for the fastest-moving particle will be exactly half the residence time for the average particle (see Appendix 1, Section H).

PART II. MICROBIOLOGICAL ASPECTS OF EGG PRODUCT PASTEURIZATION

Pasteurization of eggs is mainly concerned with the destruction of salmonellae. Microorganisms of this genus cause an infectious type of gastrointestinal illness. Occasionally salmonellosis has been cited as a main cause of death in very young and old or debilitated persons. However, generally illness consists of a gastroenteritis and fever lasting for one to several days. Over 20,000 salmonella infections in man are reported annually. Dauer (*15*) estimated that only 1 percent of human infections are reported to public health authorities.

There are over 1,000 species or serotypes of the Salmonella genus, and strains exist within serotypes. All strains tested have been found to be pathogenic for man in some degree. The main growth and death characteristics of this large group of microorganisms are described in following sections. Emphasis is placed on those characteristics that relate to eliminating salmonellae from egg products.

Growth of Salmonellae in Egg Products

The conditions that permit growth of salmonellae are summarized to provide assistance in preventing multiplication of salmonellae in egg products during processing.

Salmonellae grow readily in whole egg yolk but less readily in whites. They grow either in the presence or absence of air when temperature and nutrient conditions favor growth.

The temperature range for growth in good media is from about 50° to 115° F. Very slow growth may occur betwen 45° and 50° F. if all other conditions are favorable. Yolk products should not be held above 45° F. except for minimal times and egg whites should not be held above 55°. Table 5 shows that salmonellae and *Escherichia coli* multiply 10 times as fast at 70° as at 50°.

Salmonellae can grow between a pH of about 5 and 9 (pH is a measure of acidity: pH 7 is neutral, a pH of less than 7 is acid and a pH greater than 7 is alkaline). No growth occurs if the pH is above 9.5 to 10 or below 4.0 to 4.5. Optimum growth occurs in the pH range 6.5 to 7.5, which includes the pH of yolk and whole egg. When temperature of the medium is not optimum, the pH range over which growth will occur is reduced (that is, it may occur only between 6.5 to 7.5). Not only does growth fail to occur below pH 4.5 but salmonellae die off slowly when exposed to low pH, especially when acetic, lactic, or other organic acids are present. The rate of death depends on the pH, temperature, and concentration of acetic or other acid. This is the basis for

Table 5 — *Growth of salmonellae and E. coli in culture media*

Temperature, °F	Time required for number of microorganisms to double: Salmonellae[1]	E. coli[2]
	Hr.	*Hr.*
45		60
50	8	20
55		8
60	2	5.5
70	0.9	2
80	0.5	0.8

1/ Adapted from Gibbons and others (*21*)
2/ Adapted from Ingraham (*26*).

permitting the use of unpasteurized eggs in mayonnaise-type salad dressings (*63*).

The effects of pH and temperature on growth rate are not exactly the same, of course, for all species or serotypes. However, the limits given are suitable for practical consideration.

The number and the condition of microorganisms present initially also have an influence on growth. By condition we refer to the stage of growth, that is, whether the contaminant is in a fast-growing stage or in a semidormant stage. If it is in the fast-growing stage, growth will generally commence immediately when temperature conditions are favorable, especially when the cells are in the same or an equivalent medium. If it is semidormant, there may be a lag period of an hour or more before growth starts. Also, small numbers seem to have more difficulty getting started to grow than large numbers, especially when conditions are less than optimum. Therefore, every effort should be made to keep initial numbers low. Use of good breaking stock and good sanitary procedures throughout are important. The other main reason to strive for low numbers initially is that the degree of protection achieved by pasteurization is greater with smaller initial numbers.

The Nature of Microbe Destruction

Microbe death characteristics are important because these characteristics set the limits of safety provided by a pasteurization process. In general, a treatment that is destructive to microorganisms will kill the same percentage of the number present whether 100 or 1 million are present initially. For a process that gives a 99.9 percent kill, the MPN (most probable number) of survivors is 1 per 10 ml. (0.1 per ml.), if the count was 100 per ml. initially; it is 1,000 per ml. if the count was 1 million per ml. initially. The effectiveness of a treatment is measured conveniently by determining how long it takes to kill 90 percent of the organisms present and thus to reduce the count to 0.1 (i.e. to 10 percent) of the initial number. This time is designated the *decimal reduction time* (D) for the microorganism under the conditions used. When treatment time is twice the decimal reduction time, the numbers of microorganisms will be lowered to 0.01 of the initial numbers (i.e. during D minutes the number will be lowered to 0.1 and then during the second D minutes to 0.1 of 0.1, or 0.01). The D value is a measure of the resistance of the microorganisms to destruction under any given condition. The higher the D value the more resistant the microorganism. More details follow about the use of D as a measure of resistance.

The D value for salmonellae in whole egg heated at 140° F. is about 0.4 minute. Although D will vary with the particular microorganism, we can use this value as broadly representative. During each 0.4 minute of treatment the number of microorganisms present that have a D value of 0.4 will be reduced to 0.1 of the number present at the beginning of the particular 0.4 minute period. In 3.5 minutes the number will be reduced to 0.1 successively for 3.5/0.4 or 8.75 times or stated mathematically to a number corresponding to $(0.1)^{8.75}$ which equals 0.0000002 percent of the initial number.

The D value varies with salmonella strain, and especially with pH, sugar and salt content of media and age of culture. Therefore, considerable care must be taken in drawing conclusions from a generalized treatment. Nevertheless, such considerations are useful as guides to factors that must be considered in devising equivalent processes or minimum treatments for various products. Also, they may help to find trouble spots if any develop.

D values decrease in a fairly regular way as the temperature is raised. Obviously, less time will be needed to achieve a given kill at higher temperatures. For salmonellae, D will decrease to a tenth of its value when the temperature is raised 8° F. This value (8°) is called the Z value. It may vary from 7 to 9, but it is fairly independent of sugar and salt. Therefore, if we know the value of D at one temperature in a given product we can estimate fairly reliably the value at other temperatures. If 3.5 minutes at 140° F. is an adequate process for a certain product, then 0.35 minute would be adequate at an increase of 8° to 148°, or 35 minutes would be adequate at a decrease of 8° to 132° (see figure 2).

Heat Sensitivity of Salmonellae

Heat resistance of salmonellae varies with strain and with the pH, sugar, salt, and moisture content of the medium. It is necessary to take into consideration the fact that resistance to destruction at a given temperature varies tenfold or more depending on the medium in which the organism exists.

Variation in Heat Resistance Due to Strain. The exceptional heat resistance of *Salmonella senftenberg* 775W is well established. This strain was a single isolate made before 1950. Tests of over 300 isolates have failed to reveal any strains that are like 775W in heat resistance *(47, 48)*. The tests showed that with one exception, the most heat-resistant strain is only twice as resistant as a typical strain, *S. typhimurium*

Table 6 — *Proposed pasteurization temperatures based on heat resistance of salmonellae in egg products*

Product	Estimated relative heat resistance of salmonellae[1]	Temperatures for pasteurization in 3.5 min.	
		Calculated[2]	Proposed[3]
		F°	*F°*
Whole eggs (reference)	1.00	140	140
Yolks, plain	1.38	141.6	142
Yolks, sugared	10.0	148.3	146
Yolks, salted	11.0	148.7	146
Whites, pH 7	0.63	138	140
Whites, pH 9	0.14	133	134

1/ Estimated from Garibaldi and coworkers *(20)*, Annellis and coworkers *(2)*, Kline and coworkers *(31)*, and Osborne and coworkers *(50)*.

2/ Extrapolated on the assumption that relative heat resistance values are exact. Values for yolk products are corrected upward by the residence-time factor 74/67 or 1.1. A Z value of 8° F. was used.

3/The lower temperature for sugared and salted yolks is proposed, because the heat resistance values were estimates made by extrapolation, and experience with samples pasteurized at 146° F. indicates that the temperature is adequate.

TM-1, whereas the 775W strain is 20 to 30 times as resistant. In view of this situation and the heat sensitivity of egg products, pasteurization processes are geared to destroy salmonellae now found in egg products.

The data of Ng (*47, 48*) can be used to estimate the range of heat resistance that confronts the processor. Heat resistance of the strains tested range from about two-thirds to about twice the resistance of *S. typhimurium* TM-1. (One exception was a strain of *S. blockley* that appeared to be 4.8 times more resistant — even this contrasts with 775W, which they found to be 26 times more resistant.) Therefore, pasteurization treatments should be severe enough to give adequate kills of salmonella strains that have twice the D value observed for the test organism, *S. typhimurium* TM-1, under any given set of conditions (i.e. type of egg products, pH, salt, and sugar content).

Effects of pH and Acids on Heat Resistance. The pH has a marked effect on the heat resistance of salmonellae, as is the case for many other microorganisms *(2, 34, 50)*.[2/] Heat resistance is greatest in the pH region 5 to 6. The resistance at pH 9, the pH of egg white, is reduced to such an extent that a temperature of 133° F. at pH 9 will give about the same kill as 140° at pH 7 to 7.5. When liquid egg is acidified to pH 5 or lower with lactic or acetic acid, the resistance is less than it is when hydrochloric acid is used. There is a specific killing or sensitizing effect of the lactic and acetic acids.

Acetic acid at pH 4.1 or lower causes fairly rapid destruction of salmonellae in mayonnaise and salad dressing at room temperature. The rate of destruction is great enough so that permission has been granted for use of unpasteurized eggs in the manufacture of mayonnaise and salad dressings of specified composition (*63*).

Effect of Sugar and Salt on Heat Resistance. Both sugar and salt increase the heat resistance of salmonellae. In sugared and salted yolks, heat resistance is about tenfold greater than it is in whole egg (*20*). This means that higher temperatures or longer heating times must be used on products containing sugar and salt than on plain products. It is fortunate that protein stability is also increased in the presence of sugar and salt. Therefore, it is practical to pasteurize sugared and salted products at higher temperatures and for longer times. If the D value is tenfold higher, the temperature must be increased by 8° F., or the time must be increased tenfold.

Estimating Times and Temperatures That Give Equivalent Salmonella Kills for Various Products. It is evident from the foregoing that the heat treatment required to give equivalent killing efficiencies in various products can vary quite markedly. In estimating treatments required for equivalence, it is also necessary to consider the type of flow in holding tubes, because parts of egg liquid will move through the tubes faster than the average. Under average operating conditions, the fastest-moving particle of whole egg and whites passes through the holding tube in about 74 percent of the time for the average particle. For sugared and salted yolks and blends of 28 percent or higher solids, the fastest-moving particle passes through in about 67 percent of the time for the average particle (*28*).

2/ Also unpublished results.

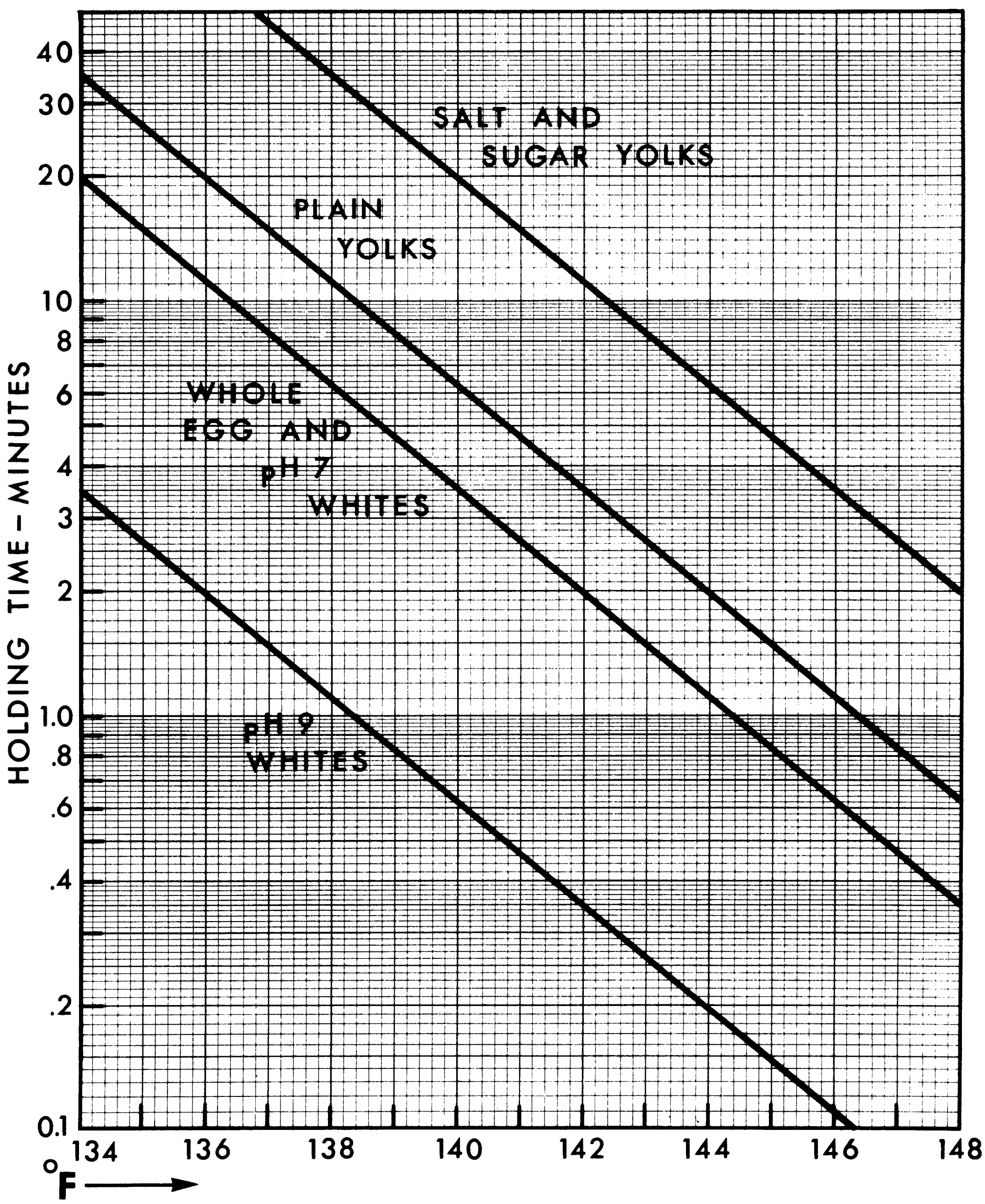

Figure 2. — Times and temperatures that yield approximately equal degrees of pasteurization effectiveness for various egg products. Lines are estimates of minimum conditions applicable under present processing procedures. (See table 6 and footnotes thereto.)

The relative heat senitivity of salmonellae in egg products has been estimated from available data, table 6. The proposed temperatures for the various products utilize both the available salmonellae destruction data and quality retention information. The proposed temperature for salted and sugared yolks, which is lower than is indicated by the simple extrapolation of decimal-reduction-time data, seems justified as explained in footnote 3 of table 6.

The known relation between time and temperature required to produce approximately equal pasteurization effectiveness has been used to construct figure 2. Temperatures needed to correspond to selected times (or times needed to correspond to selected temperatures) can be read from the figure. For example a 3-minute holding time will require a temperature of 134.5° F. for pH 9 whites, 140.5° for whole eggs, 142.5° for yolk, etc. Or a temperature of 142° will require 2 minutes for whole eggs, 3.5 minutes for yolks, and 11 minutes for sugared and salted yolks. At 144° sugared and salted yolks require 6.2 minutes. Some time and temperature combinations are not practical. Above 135° buildup on plates is difficult to avoid for pH 9 whites and care must be exercised at 134°F.

PART III. PASTEURIZATION METHODS

Effectiveness of Pasteurization

Pasteurization under the conditions to be described generally reduces the total bacterial count of whole eggs and egg white by about 99.9 percent. That is, about one bacterium in 1,000 survives. Because salmonellae are more easily killed than many other egg contaminants, the kill of salmonellae greatly exceeds this. For example, pilot plant study indicates that the process has the potential of killing 99.999999 percent of common types of salmonellae, if present in egg white. This means that only about one salmonella in 100 million survives. The results of the pilot plant study are consistent with those of laboratory studies and with results on whole eggs. It means we would expect less than one salmonella in a ton of egg product, even if the egg product initially contained as many as 100 salmonellae per gram (i.e. about 100 million per ton).

Breaking Stock

The margin of safety provided by pasteurization is directly related to the microbiological quality of the egg product being pasteurized. It is not necessarily related to shell egg grades or Haugh units. CFR 7, section 55.80 of the Regulations Governing the Grading and Inspection of Egg Products *(62)* classifies shell eggs that may be used in the processing of egg products. Eggs for breaking shall be of edible interior quality. They shall be chicken eggs, except that edible turkey, guinea, duck, and goose eggs may be processed if they are processed separately and properly labeled. The shells shall be sound and free of adhering dirt and foreign material except for a few specified conditions such that quality of the contents would not be adversely affected. Eggs with meat or blood spots may be used if the spots are removed in an acceptable manner. Special handling methods are required for eggs received in cases having strong odors and for eggs with clean shells that are damaged in candling or transfer or both. Loss and inedible eggs, which are not to be used, are defined in detail in reference *62* (par. 55.80).

Pasteurization of Whole Egg and Yolk Products

Whole Eggs. The current pasteurization method for whole egg is based on laboratory research conducted during and immediately following World War II (*54, 65, 66*) and on the commercial application of the research results (*22*). Treatment is in excess of that found by Winter and others (*66*) to be adequate for destruction of levels of 10^5 to 10^6 per ml. for all but one of the types of the salmonella organisms that they added to liquid whole egg. The exception, a strain of *Salmonella senftenberg,* has not been found in egg products since that time. The early work was recently confirmed by a report that more than 10^7 per ml. of added *S. typhimurium* were destroyed in 2 minutes at 140° F. in a small commercial-type HTST equipment (*60*).

CFR7, Chapter 1, Part 55, Section 55.101 of the regulations governing the Grading and Inspection of Egg Products (*62*), reads in part as follows: "Strained and filtered liquid whole egg shall be flash heated to not less than 140° F. and held at this temperature for not less than 3.5 minutes." This definition of the pasteurization treatment for whole egg is imprecise because laminar flow occurs to considerable and varying degrees in pasteurizing equipment. Therefore, the fastest moving particle, which largely controls the effectiveness of the treatment, may reside in the holding tube for as little as one-half the average time. Since this is the case, since the current pasteurization requirement for whole egg has a long history of adequacy, and since recent decimal-reduction-time studies provide confirmation, the more precise statement may be made that *every particle of strained and filtered liquid whole egg shall be rapidly heated to not less than 140° F. and held at that temperature for not less than 1.75 minutes.* This is based on and requires a 3.5-minute average holding time to assure that the fastest-moving particles are held at least 1.75 minutes when fully developed laminar flow occurs. Unless otherwise indicated all subsequent references to holding time will refer to the average time.

Regulations for pasteurization of liquid whole eggs established by other countries generally require a higher temperature than is required in the United States (*45*). The heat treatment required in England specifies 64.4° C. (148° F.) for a minimum of 2.5 minutes, although the need for such a high temperature has not been demonstrated (*18*), and operation is more difficult because of buildup of egg in the equipment. However, this is a permissible method under the USDA regulations. One advantage of pasteurizing at the high temperature is that an enzyme test (alpha-amylase) is available to indicate compliance with the pasteurization regulations. Amylase is not a useful test under U.S. conditions, because it is not destroyed by the U.S. heating conditions. Experiments to establish treatment conditions used in England were carried out by use of a high-temperature, short-time pasteurizing unit and cooling cycles operating at a rate of 500 gallons per hour with a 2.5 minute holding time (*25*). Liquid whole eggs were inoculated with *S. gallinarum* (400,000 per ml.) or *S. typhimurium* (200,000 per ml.). The salmonellae were destroyed at all temperatures ranging from 143° to 151° F. The use of 148° represents a very wide margin of safety. However, the more severe treatment increases the stability of the egg against microbial spoilage when distributed in liquid form, as practiced considerably in England.

Frozen whole eggs pasteurized by the U.S. method have been used successfully for many years in this country in the commercial preparation of a wide variety of foods. In recent commercial-scale tests pasteurized frozen whole eggs presented no major technical problems when they were used in sponge cakes, layer cakes, devil's food cakes, eclair and cream puff shells, and custards (*3*). Tests included three types of sponge cakes: the unleavened, the commercial emulsified, and the continuous-mix cakes. In general, the flavor, appearance, tenderness, volume, and eating quality of the products made from pasteurized and unpasteurized whole egg are fully equivalent.

Pasteurization of whole eggs and fortified whole eggs does, however, affect the appearance and performance of the product to some extent. Slight and variable reductions in viscosity of pasteurized frozen whole eggs after thawing have been encountered (*3, 60*). Freezing, homogenization, and mechanical treatment involved in pumping and forcing the liquid through the pasteurizing equipment appear to have more effect on viscosity than does the heat treatment. Early laboratory-scale tests of pasteurized eggs showed no effect of pasteurization on the thickening power in custards but minor effects on whipping rate and sponge cake volume (*23, 41*). The slightly slower whipping rate found for pasteurized whole eggs can be corrected in commercial production by slight adjustments in formula, whipping time, or mixer speed (*3*).

In recent laboratory tests the foaming power of pasteurized whole eggs tested before freezing was not affected, but the pasteurized frozen whole eggs after thawing required longer beating times than unpasteurized. The volumes of sponge cake prepared from the eggs were not affected (*60*). Homogenization of the pasteurized product made it approximately equivalent to the unpasteurized product in foaming power, although the product was less viscous. Whole eggs pasteurized at 146° to 148° F. for 3.5 minutes showed significant damage.

Problems have been encountered occasionally in the use of pasteurized eggs in cream puff shells (*5*). Whether excessive heat treatment during pasteurization was responsible for the loss of emulsifying function is not known. The problem was temporarily solved by increasing the level of eggs in the formula. It is generally agreed that the performance of properly pasteurized whole eggs can equal that of the unpasteurized product with no or only minor alterations in formula or mixing procedure (*17*).

Whole eggs pasteurized by the English method at 148° F. tested by English bakeries in Madeira cake, Swiss roll, choux pastry, and various cakes elicited few complaints. Because of differences in egg product usage, evidence of damage would be more frequent if the British method were adopted in the United States (*18, 60*).

Plain Yolks, Salted Yolks, Sugared Yolks, and Blends. The regulations governing the grading and inspection of egg products (*62*) specify that all egg products shall be flash-heated to such temperatures and held for such times as will give salmonella killing effects equivalent to the prescribed treatment for liquid whole eggs. Tests are being conducted to provide the information needed to establish equivalent treatments for these products. However, on the basis of tests thus far completed, the *tentative* holding times and temperatures listed in table 7 are proposed for these products. Other equivalent times and temperatures can be read from figure 2.

The more severe pasteurizing requirements for yolks are based on the finding that salmonellae are

Table 7. — *Proposed pasteurization conditions for various egg products*

Product	Temperatures	Holding time for Fastest particle	Holding time for Average particle
	°F.	*Minutes*	*Minutes*
Plain yolks, whole eggs with yolks to 33 percent solids, and sugared whole eggs.	142	1.75	3.5
	140	3.1	6.2
Sugared yolks, salted yolks, and salted whole eggs (10 percent sugar or salt added)	146	1.75	3.5
	144	3.1	6.2
Blends (27 to 35 percent solids)	142	1.75	3.5
Blends (less than 27 percent solids and less than 1 percent sugar and salt)	140	1.75	3.5

1.5 to 2 times as resistant in yolks as in whole eggs, as found by recent work of Garibaldi and coworkers (*20*), who extended the earlier observations of Anellis and coworkers (*2*) and Osborne and coworkers (*50*), and on observation of the flow characteristics of egg products. The more severe requirements for salted yolks, sugared yolks, and blends are based on the fact that sugar and salt increase the resistance of salmonellae to heat and on the influence of the flow characteristics of egg products (see Parts I and II).

Batch Pasteurization. Batch pasteurization of whole eggs has proved effective in studies conducted at the University of California at Davis (*53*) and in practice (*10*). Generally, equipment is designed to handle batches of 40 to 400 gallons. A holding period of 13 minutes at 133° F. is equivalent to the treatment received by the fastest-moving particle in fully developed laminar flow in liquid held for an average of 3.5 minutes at 140° F. Since 135° F. for 15 minutes does not damage whole eggs, some States have set this as the minimum condition for batch pasteurization.

Considerable care must be exercised in batch pasteurization. The headspace as well as the liquid must be heated. Filling and stirring must be conducted so that very little foam occurs because the heat will not penetrate to the center of a thick foam. The headspace temperature is generally required to be 5° F. above the pasteurization temperature. Further studies and experience with batch pasteurization may make some modification of these tentative conditions desirable. If the design and operation of the pasteurizer are such that foam height is greater than 1 to 2 inches, the heating time should be increased to assure adequate heating in the center of the foam. Roger W. Dickerson, Jr. (personal communication) has made recent studies that indicate that it may be necessary to hold the samples for a total of 30 minutes when foam is excessive, ranging up to 6 inches in height.

A complete batch pasteurization unit would consist of a stainless steel jacketed vessel with cover and with agitator blades, automatic controls and recording devices, hot water boiler, and chilled water. Heating from 40° to 135° F. should take less than 1.5 hours and cooling to 40° F. should be completed in 1.5 hours also. Steam is injected automatically into the headspace to maintain headspace temperature. The equipment must be sanitary in construction and readily cleaned.

Pasteurization of Egg Whites

Damage to egg white proteins at the usual pasteurization temperature of 140° F. prevented commerical pasteurization of egg whites until 1964. In that year a way to increase the resistance of egg whites to heat was discovered in the Western Utilization Research and Development Division of USDA. Shortly after this, pasteurization became mandatory for liquid egg whites processed under USDA inspection. At present there are five approved continuous processes by which liquid egg whites can be pasteurized and thus qualify to bear the label "pasteurized": (1) A process for pasteurizing egg whites at pH 7 consists of adding a solution of aluminum sulfate to stabilize conalbumin and sufficient lactic acid to lower the pH to 7 followed by pasteurization at 140° F. for 3.5 minutes (1.75 minutes for fastest particle). (2) A heat-plus-peroxide process that consists of heating pH 9 egg whites to 125° and holding for 1.5 minutes followed by injection of peroxide into the holding tube and holding for 2 minutes, cooling, and adding enzyme to decompose residual peroxide. (3) A heat-plus-peroxide process that consists of injecting peroxide into the pH 9 whites between the regenerator and heating plates, heating to 125°, holding for 3.5 minutes, cooling and adding catalase to decompose residual peroxide. (4) A heat treatment that consists of exposing pH 9 whites to a vacuum between the regenerator and flash heater followed by heating to 134° and holding for 3.5 minutes. (5) A treatment that consist of heating pH 9 whites to 134° and holding for 3.5 minutes.

These processes are described in the following pages. However, processors interested in a particular process should confer with the developer for permission to use the process and for further details.

Pasteurized egg whites are being used successfully in all bakery products. However, their appearance differs from unpasteurized whites, and slight adjustments may be required in the bakery formulas or methods. Pasteurized whites are usually less viscous and may tend to spatter within the bowl during early stages of whipping. Clumps of foamy thickened white may be suspended in thawed pasteurized whites; however this material is functionally active and readily dispersed. The amount of foam is minimized if egg cans are not filled too rapidly. Whites pasteurized near pH 7 by the process listed first (above) require less than the usual amount of acid in bakery formulas. They are more opalescent or turbid than whites pasteurized by other methods. Pasteurized white may require a longer whip time than unpasteurized. Whipping aids or an increased beater speed reduce the whip time.

Pasteurized frozen egg whites have improved tolerance to overbeating. Whipping of unpasteurized whites for a longer time than is required for optimum specific gravity lowers the volume of angel cakes prepared from the white. Pasteurized egg whites, with or without whipping aids, can be subject to more overbeating than unpasteurized whites without decreasing the volume of the angel cakes prepared from them (*3*).

Whipping aids frequently will be neither necessary nor desirable additives in pasteurized egg whites. However, where shorter whip times are desired this can be accomplished by use of a whipping aid.

Many frozen pasteurized whites contain additives that are incorporated as whipping aids. Triethyl citrate (TEC) (*33*) and triacetin (TA) (*40*) can be used to counteract the retardation of whipping rate caused by pasteurization of the egg whites. They are equally effective with any method of pasteurization and may be added before or after pasteurization. Triethyl phosphate (TEP) is also effective but has not been approved for use (*12*). These same whipping aids counteract the retardation in whip time caused by heating unmodified egg whites in the range 125° to 134° F., while sodium lauryl sulfate (SLS) (*42*), the whipping aid used for improving the foaming power of spray-dried whites, does not improve the whipping rate of heat-treated liquid whites (*31*). Lipase is used in some cases to counteract the effect of excess yolk in whites (*46*). This would be effective only when sufficient time at a favorable temperature is permissible, so that the lipase can hydrolyze the fat. If the lipase preparation contains excessive amounts of proteinase, the foam structure may be weakened.

For the pH 7 process, addition of whipping aid can be accomplished very simply by incorporating it in the stabilizing solution. To obtain a final concentration of 0.05 percent whipping aid in the egg whites, the stabilizing solution should contain 9 percent of the whipping aid. If less than 0.05 percent of whipping aid is desired, then proportionally less whipping aid should be added to the stabilizing solution. The stabilizing solutions containing whipping aids are stable for serveral months at room temperature, and the effectiveness of the whipping aid is not diminished by pasteurization treatment at the pH of stabilized egg whites. Where whipping aid is added directly to egg whites, the amount required should be added to a small part of the batch, mixed thoroughly, then added to the batch. The reason for this is that the whipping aid is so dense that it may sink to the bottom of a big batch and not be mixed in uniformly.

Process for pH 7 Whites. Research in the U.S. Department of Agriculture (*13, 36*) resulted in a process for stabilizing liquid egg whites so that they can withstand the pasteurization conditions applied to whole eggs (140° to 143° F. for 3.5 to 4 minutes). The process consists of adjustment of the pH of liquid whites and the addition of a suitable metal salt.

When an acid (preferably food grade lactic acid) is used to lower the pH of egg whites to a level of 6.8 to 7.3, the heat stability of the egg white proteins ovalbumin, lysozyme, ovomucoid, and ovomucin is increased, and viscosity changes on heating are prevented. At this pH, the globulins G_2 and G_3 are adequately stable to temperatures of 140° to 144° F. for several minutes, but conalbumin is not. This particular protein can be stabilized by the addition of iron or aluminum salts. The metallic ions are capable of combining with conalbumin to form a complex that is more heat-stable than the free protein.

Although iron salts are as effective in stabilizing egg whites as are the aluminum salts, they cause the egg whites to become pink. This is not necessarily a disadvantage, since the color fades upon further acidification of the whites and disappears during cooking. A disadvantage, from a microbiological point of view, is that iron salts tend to accelerate growth of the small number of spoilage organisms that generally survive the pasteurization treatment.

Sodium citrate, which is sometimes used as an additive in egg white, interferes with the metal stabilization of conalbumin. Although the addition of larger amounts of metal salt will counteract the citrate, it is preferable to avoid adding citric acid or sodium citrate to egg white before pasteurization.

Whole eggs can be pasteurized without coagulation because of the lower pH and the presence of enough iron in the yolk to react with, and thus stabilize, the conalbumin in the white.

Pasteurization procedure:

A. Materials needed:

Lactic acid (food grade).

Aluminum sulfate ($Al_2(SO_4)_3 \cdot 18H_2O$) (food grade).

Whipping aid (not needed for stabilization but can be added with stabilizing solution).

B. Preparation of stabilizer solution to be added to egg white: Prepare 25 percent lactic acid by adding 28 parts of 88 percent lactic acid to 72 parts of water; or 50 parts of 50 percent lactic acid to 50 parts of water. Add 6 lb. of aluminum sulfate to each 100 lb. of 25 percent lactic acid.

C. Addition of stabilizer solution to egg white: Measure out an amount of stabilizer solution equal to 0.6 percent of the white (i.e. 6 lb. or 6 pints per 1,000 lb. of white). Add the stabilizer solution carefully to rapidly stirring egg white and allow for thorough mixing. (A good way is to trickle the solution into the whites being stirred in a churn during a 10- to 20-minute time period depending on the size of the batch.) The solution must be added slowly with vigorous stirring to avoid local high concentrations of acid that may coagulate some of the protein. If mixing is not thorough, some of the whites may not be stabilized sufficiently to prevent cooking on to the pasteurizer plates.

Check the pH of the whites (preferably with a pH meter). It is satisfactory if pH is between 6.8 and 7.3. If the pH is above 7.3, add more stabilizer solution. If it is below 6.8, add more egg whites.

D. Pasteurization: The required minimum treatment is 140° F. for 3.5 min. Adjusting the preheaters, the number of plates, and the flow rates so that the hot side of the heat exchange surface is below 145° will facilitate continuous operation of the equipment.

Use of pH 7 egg whites will require less "acid cream" or cream of tartar in bakery formulae. In preparing angel food cake, for example, only about two thirds to three fourths of the usual amount is needed. Atkin *(3)* reported "acid cream" ranges for different types of egg whites used for angel food cake, as shown in table 8.

The appearance of the pasteurized egg white when beaten to its optimum density will be more moist than the "dry peak" to which normal egg white is beaten. For this reason, beating to the recommended density rather than to the appearance of a typical peak is advisable.

Table 8. — *Acid cream levels for angel food cake*

Treatment of egg white		pH of egg white	Acid cream range (oz./10 lb. egg white)
Pasteurization	Additions		
None	None	8.8 to 9.1	2 3/8 to 2 5/8
None	buffer	9.0 to 9.3	2 7/8 to 3 1/8
None	acid buffer	7.8 to 8.2	2 to 2 1/4
Pasteurized at 140° 3.5 min.	aluminum sulfate lactic acid	7.0 to 7.3	1 1/2 to 1 3/4

Heat Plus Peroxide Process (a). Ayres and Slosberg (*4*) showed that hydrogen peroxide could be used to destroy salmonellae in egg white at or near room temperature. This observation did not lead to a commercial process at that time. In 1957, Armour and Company patented a process for pasteurizing liquid egg white by a combination of heat treatment and peroxide use (*39*). The pasteurization is accomplished at the natural pH of egg white. Commercial application was developed in 1966. The process was recently described by Rogers, Sebring, and Kline (*56*).

As indicated by Ayres and Slosberg (*4*), hydrogen peroxide can be used to destroy salmonellae in egg white at a temperature below that at which major damage to functional properties of the protein occurs. After treatment the hydrogen peroxide is decomposed to water and oxygen by addition of the enzyme catalase according to the following reaction:

$$2H_2O_2 \xrightarrow[\text{enzyme}]{\text{catalase}} 2H_2O + O_2$$

Catalase is naturally present in egg white and unless inactivated, will start to destroy the peroxide before the treatment is complete. To minimize this, the Armour method holds the egg white at 125° F. for 1.5 minutes, which is claimed to inactivate part of the catalase. Peroxide is then added and heating is continued for 2 minutes.

The effectiveness of the process in killing salmonellae is due to the combined effect of heating at the normally high pH of egg white and the addition of H_2O_2. Without the peroxide, tests for salmonellae were positive even at 130° F. and the total plate count was reduced only about 90 percent instead of 99.9 percent. Commercial experience has confirmed the laboratory tests.

The procedure is as follows: Egg whites are heated in the usual heat exchange equipment to 125° to 127° F. and held at not less than 125° for 1.5 minutes. A 10 percent solution of hydrogen peroxide is continuously metered into the holding tube at the rate of 0.5 lb. per 100 lb. of whites in a direction opposite to the flow of the egg white to assure optimum mixing. The rate of addition must be accurately coordinated with the egg white flow rate at all times to assure that the concentration of 0.05 percent peroxide is uniformly achieved.

The mixture is held at not less than 125° F. for 2 minutes. The pasteurized egg whites are cooled to 45° and passed into a receiving vat containing enough catalase to decompose the residual hydrogen peroxide. Excessive foaming due to formation of oxygen in the pasteurizer or the receiving vat can be reduced by adjustments in procedure. Foam formation in the receiving vat is evidence that peroxide is being decomposed. However, test paper for determining the presence of peroxide is available. This may be used to make sure peroxide is present at the end of the holding period and later to show that the added catalase completely destroys it. Care must be taken in all steps that follow pasteurization to prevent re-contamination of the egg white.

Heat Plus Peroxide Process (b). This process was developed by Standard Brands and utilizes the bactericidal effect of peroxide on microoganisms. After the egg white leaves the regenerator section of the pasteurizer and before it enters the heating section, a 10 percent solution of hydrogen peroxide is added at not less than 0.875 lb. per 100 lb. of whites. This mixture is then heated to not less than 125° F. for not less than 3.5 minutes. The flow diversion valve is to be adjusted so that all liquid not reaching 125° will be diverted. It is then cooled to 45° or lower in the cooling section of the pasteurizer and pumped to a holding vat or drawoff tank. Sufficient catalase may then be added to decompose the residual hydrogen peroxide.

In this process the temperature of the egg white does not exceed 95° to 98° F. for more than 15 to 20 seconds before the hydrogen peroxide is added. Preferably, the hydrogen peroxide should be added to the system when the egg whites leave the regenerator section and have been held at a temperature of about 95 to 98° for less than 15 seconds.

Heat Plus Vacuum Process. Tests conducted by the Ballas Egg Products Co. have resulted in a method for pasteurizing egg whites at 134° F. with a 3.5 minute hold. The process calls for a vacuum chamber operating with about 17 to 20 inches of vacuum. The chamber is preferably positioned in the line after the eggs have passed through the regenerator. Ballas Egg Products Co. has indicated that inclusion of the vacuum chamber reduces "cooking" of egg whites on the plates during heating and yields a higher beating rate and greater sugar-carrying capacity of the whites. The reason for and degree of the beneficial effects of the vacuum chamber have not been established. The salmonella kill reported is the same within experimental error whether or not the vacuum chamber is included in the process.

Plain Heat Treatment Process. Kline and coworkers (*32*) showed that salmonella kills in egg white held at 134° F. for 3.5 min. approximate the kills for the accepted whole egg process. An equivalent treatment is 132° F. for 6.2 min. (extrapolation of figure 2). The maximum temperature difference between the heating water and the product at the outlet of the heating section should be as small as practicable, preferably not exceeding 2° to 3° to minimize coagulation on plates, to facilitate continuous operation, and to minimize damage to whipping properties. Whipping aid can be added to compensate for increased whip time, which occurs to a variable degree from batch to batch of egg white.

Heat Treatment of Egg White Solids.[3] Heat treatment of egg white solids to destroy salmonellae was proposed by Ayres and Slosberg in 1949 *(4)* and studied further by Banwart and Ayres in 1956 (*6*). These studies led to the general adoption of a dry heat treatment for egg white solids for the destruction of salmonellae.

Moisture content, as well as temperature, affects the rate of salmonella destruction and also the way the treatment affects functional properties. Research results and industry experience indicate that a satisfactory treatment condition is 125° to 130° F. for 7 to 10 days exclusive of come-up time for powder having approximately 6 percent moisture. Higher temperatures and shorter times may be used but data are not adequate on this point.

Under patent number 2,982,663, Bergquist (*7*) described a pasteurization process for whites enroute to enzyme desugarization, spray drying, and subsequent "hot room" treatment for the production of egg albumen solids of low bacteria count. It was emphasized that both the pasteurization of the fresh liquid and the heat treatment of the finished product were necessary for the success of the method.

Spray-dried whites should be filled into bulk packages as they discharge from the drier and the packages moved immediately to the "hot room". Otherwise extended holding (3 to 4 days additional) may be required to bring the temperature of the product in the center of the package up to the hot-room temperature.

Pan-dried egg white also can be subjected to similar storage treatment at the described temperatures for salmonellae destruction. This product is normally filled into bulk containers at room temperature. A 10- to 14-day storage time may be required to bring all products up to treatment temperature for optimal bacterial destruction.

The hot room must be adequate to hold the volume of product requiring treatment without overcrowding against walls. Aisle space should be sufficient to facilitate movement of product to and from treatment on a lot basis. The room should not be adjacent to cooler and freezer facilities, and the walls of the room should be sufficiently insulated to minimize gross heat loss.

A heat supply adequate to maintain the temperature range selected for use is needed. Fans, either auxiliary or as a part of the central heating system, should provide noticeable air movement in all areas of the room. A record of room temperature should be kept on a continuous temperature recorder. Auxiliary thermometers should be stationed in the center and extremities of the room to confirm uniformity of air and heat distributon.

Drums and other packages of dried whites undergoing treatment should be handled on skids and stacked in a manner that will allow air circulation around the unit packages.

Room condition (air movement, stacking, and temperature) should be checked daily. A daily log must be kept on product undergoing treatment to assure movement of product to and from treatment on schedule. Following treatment, products should be sampled aseptically for bacteriological and performance examinations.

Brief Comments on the Destruction of Salmonellae in Egg Products by Ionizing Radiation and Epoxides

The following comments give some indication of the potential of other treatments for destroying salmonellae in egg products. None is approved at present. Because of the heat sensitivity of egg products, numerous workers have sought to develop "cold" pasteurization treatments. Ultraviolet and high energy radiations and chemical treatments have been found to be effective but generally the treatments have drawbacks of one kind or another.

Radiation pasteurization offers the unique feature that a frozen product such as a 30 lb. tin of eggs can be pasteurized without thawing or opening the package. It is additionally attractive because it permits in-package pasteurization, which avoids recontamination, and it does not heat-treat the product. Ionizing radiation pasteurization of food products to destroy salmonellae can be accomplished at about

[3]/ This section was prepared by J. M. Gorman, Seymour Foods Division, Norris Grain Co., Topeka, Kan.

one-tenth the dose required for sterilization, that is, at 0.2 to 0.5 Mrad (*8, 9, 11, 27, 35, 44*).

Beta and gamma energy are equally effective in killing salmonellae. However, gamma rays would be needed to penetrate thick containers such as a 30-lb. can of egg. The mechanism of death by irradiation differs from the mechanism of heat destruction. For example, the highly heat resistant *S. seftenberg* 775W is, if anything, slightly less resistant to radiation than other isolates *(8, 44, 49)*.

Yolk-containing products show flavor changes at pasteurizing doses of radiation. The change is slight enough that pasteurized products probably would be satisfactory for sponge cake. The flavor change is readily detected and is objectionable in scrambled eggs and custards (*8, 55*). The off-flavor largely volatilizes on spray drying *(8)*. Mossel *(44)* observed somewhat more serious damage to liquid whole eggs and concluded that the process was not promising. Since heat treatment as used in the United States causes little or no damage to functional properties and no flavor change, heat pasteurization is definitely the method of choice at present.

Egg white products are only slightly damaged by pasteurizing doses of radiation. A commercial laboratory found that the flavor, volume, and texture of angel food cakes made from egg white solids irradiated at 0.7 Mrad did not differ from cakes made with regular commercial whites *(49)*.

The quality of shell eggs is lowered by a dose level of 0.1 Mrad *(52)*. An unnatural odor is produced and quality (Haugh units) of the white is lowered. Neither radiation sterilization nor radiation pasteurization of shell egg contents appears promising.

The cost of treating foods with 0.56 Mrad (a pasteurizing dose) was estimated to be 0.75 cent per lb. for gamma radiation, 0.35 cent for beta radiation, and 0.50 cent for X-ray radiation at a nominal plant capacity of 15,000 lb. per hour (*38*). These costs include amortization of capital costs, which were estimated at $2.7 million for gamma radiation, $0.36 million for electron radiation, and $1.4 million for X-ray radiation.

Epoxides can be used to destroy salmonellae and other microorganisms near room temperature according to Sair (*58*) and others cited in his report. Ethylene and propylene oxides (typical epoxides) are gases that have been used to sterilize spices, gums, and other materials. These oxides have been shown to be effective in a simple fumigation process on spray-dried egg powders, but not on pan-dried egg white. The effectiveness is influenced by the moisture content of the powder, and the epoxides may react in some cases to give chlorohydrins that are undesirable.

Approval to use epoxides to "pasteurize" egg products does not appear likely in the near future. However, the applicability of these gases to powders makes them remain attractive. Beta-propiolactone is another epoxide that has potential for use on liquid egg materials.

PART IV. CONSTRUCTION, INSTALLATION, TESTING, AND OPERATION OF PASTEURIZERS

Maximum assurance that pasteurization of egg products will be successful requires careful attention to the installation and testing of suitable equipment as well as to the operation of the equipment. As far as possible such safety factors as temperature controls, recording thermometers, and a flow diversion valve to divert underheated product are built into the system. However, most important is the human element. This applies not only to operation but also to handling of product to assure that recontamination does not occur. The manager, foreman, and particularly the operator must not only check the pasteurizing and packaging or filling operation but must understand why various precautions are necessary.

A detailed outline of USDA Accepted Practices for the Sanitary Construction, Installation, Testing, and Operation of High-Temperature Short-Time Liquid Egg Pasteurizers is presented in Appendix 1, sections A to K. The individual units and sanitary construction of the equipment are the responsibility of the firm supplying them, and in many instances the processor asks the equipment firm to be responsible also for the layout and installation.

Construction Quality

Sanitary standards for equipment are mentioned at different points throughout Appendix 1. For a particular piece of equipment the standard is the applicable 3A Sanitary Standard (see Appendix 2) developed for milk and milk products.

These minimum standards have been formulated by the 3A Sanitary Standards group composed of food processors, government sanitarians (national, State, and local), and the food equipment industry. The standards represent a convenient guide that reduces unnecessary expense that would result from a multiplicity of specifications. Equipment purchased under the specification that it conform to applicable 3A Sanitary Standards should meet the latest draft of these minimum sanitary requirements. Their use has a background of 20 years of successful service to the dairy and other branches of the food industry in insuring the availability of durable equipment that is easily cleaned and sanitized.

Materials for product contact surfaces should be impervious and readily washable so that they will not harbor spoilage or disease bacteria that may contaminate the product. Stainless steel best meets this requirement. Plastic and rubber are acceptable for sealing applications. To conform to food standards, these materials must meet certain specifications (sections D, E, and I) so as to withstand contact with fats, food acids, cleansers, chlorine, or other bactericidal solutions.

Nonproduct contact surfaces should be smooth and readily cleanable so that they can be maintained free from any accumulation of mold, dirt, or other contaminating material in the food processing room.

The construction or fabrication of egg processing equipment should emphasize ease of cleaning. All corners should have adequate radii and all welds should be ground smooth (as detailed in section E.1). All details must permit maintenance in a scrupulously clean, sanitary condition so as to avoid contamination of the product during or following pasteurization.

Equipment

A *timing pump* of the *metering, positive displacement* type should be provided and sealed to limit the maximum rate of flow through the pasteurizer to its rated capacity, because the holding tube is sized to maintain the required holding period for this maximum capacity. Lower pumping rates are obtainable by means of a variable-speed mechanism. Details on this are given in sections E.4, E.5.4, and K.3.

The purpose of the *holding tube* is to provide the required hold of every particle of product at the required pasteurizing temperature. To avoid air pocketing that would reduce the holding period of a given pipe, the holder tubing must slope continuously upward at not less than one-fourth inch per foot as detailed in section E.5. Small-diameter tubes with higher product velocity lessen the chances of air pocketing or foam buildup in the tubes. Pressure in the holding tube also should be sufficient to prevent air release from the product. One plant prevented air from being released and hence prevented foam buildup in salted yolks by maintaining a pressure of about 20 p.s.i. at the outlet of the holding tube.

The holding tubes should be protected so that cooling of the product is minimized as it flows through the holding tubes. Uninsulated tubes in the open, or in enclosures that permit natural room air circulation, allow temperature drops of 2° to 5° F.; insulated tubes allow 1° to 2° F. If the tubes are surrounded by air at a temperature just below that of the product, practically no temperature drop occurs. This condition can be accomplished by enclosing the holding tubes in an insulated jacket and heating the enclosed air with steam or hot water coils, or electrically with strip heaters. Automatic control of air temperature must be provided, so that the product temperature is not raised in the holding tubes. In addition to saving of heat, film formation on plates of the heating section and heat damage to the product are minimized if the temperature of the product entering the holding tube does not have to allow for a big temperature drop during holding. This is especially important for some of the pasteurization methods used on whites.

Tests have determined that the wide range in viscosity and the presence of conductive materials in liquid egg products make impracticable the customary method of measuring the holding time for the fastest moving particle by means of salt injection in water or in the product itself. Three procedures that will provide such information have been developed (*29, 45*). However, the need to measure the holding time of the fastest-moving particle is avoided in practice by basing the required treatment on the time that would result for complete laminar flow. The average hold time required will in this case be twice the minimum residence time required. Therefore, under this system only average residence times need to be determined (see section H).

The flow-diverison device with recorder-controller is necessary to provide automatic control of the pasteurizing operation and to give maximum assurance that no material escapes exposure to the temperature and holding period required for the destruction of salmonellae and reduction of spoilage. The flow diversion valve operates to divert any underheated egg liquid back into the raw egg supply tank for repasteurization before it can mix with already pasteurized product held in storage tanks awaiting placement in final containers. Daily inspection, testing, and recording of the flow diversion point on this controller is essential to maintain the proper operation and to assure that underpasteurized eggs do not contaminate properly pasteurized product. Details of the construction, testing, and operation of these instruments are covered in sections E.6, E.7, and E.8.

Pasteurizing equipment units must be connected with *sanitary piping*. By custom and definition this means smooth, polished, stainless-steel piping free from roughness or crevices in which disease or spoilage organisms can lodge and contaminate the liquid egg at any point particularly following pasteurization. Detailed specifications, installation, and operation guidelines on piping are given in section E.9.

Other component parts, such as a control panel to centralize operation of the pasteurizer for the most convenient and efficient operation, are listed in Sections E.12 through E.17.

Installation

A properly installed and tested liquid-egg pasteurizer will last for a long time, often until enlargement is needed. Therefore it pays to do the job thoroughly and carefully so as to have a well-functioning, trouble-free installation that will produce quality products at minimum operating and maintenance expense. Guidelines on installation are detailed in section F.

Application to install and operate a new egg pasteurizer should follow a definite routine and plan to assure availability of all facts. When the plan is, or will be, under the U.S. Department of Agriculture's supervision, apply to the Grading Branch, Poultry Division, Consumer and Marketing Service, U.S. Department of Agriculture, Washington, D.C. 20250. When the egg processing plant is not under USDA supervision, apply to the cognizant State or local inspection agency. Much time and lost motion are saved when an adequate application, such as is detailed under section L, is prepared in collaboration with the plant's equipment supplier and is submitted for acceptance as conforming to accepted practices for the HTST (high-temperature short-time) pasteurization of liquid eggs.

Leakage of raw product into pasteurized product as a result of defective plates in the regeneration section will not occur if a higher pressure is maintained on the pasteurized side of the plates. To accomplish this a pressure control system such as that used for milk is required. Because the fluid flow problems are more variable and complex for egg products than for milk, studies have been undertaken to determine the requirements for such systems.

For a number of years a lower pressure on the pasteurized side of regenerator plates has been permitted in plants under USDA inspection. Daily inspection of plates by the USDA inspector was required to detect etched or damaged plates, so that they could be removed before actual leaks occur. It is questionable whether this practice will continue to be permitted. Companies making a new or modifying their present installation should take this into consideration as well as information now being developed on the most efficient and safe installations for regeneration (sections E.3.2, E.3.2.1 and K.2.1).

After effective pasteurization of the liquid egg product, extreme care must be taken to *prevent* recontamination with salmonellae. (See guidelines detailed in Section J.) Prevention requires a filling or packaging room separate from the breaking or raw product processing room, since airborne and manual contamination from the raw eggs must be avoided. The filling room should be maintained under positive pressure by a filtered, safe, outside-air supply system. This will avoid exposure of the pasteurized product to contaminated air during filling. Note that drawing or pumping from a tank of pasteurized product draws air into the tank to replace the liquid withdrawn. Protection of the pasteurized product is assured only if the replacement air in the filling room is clean.

Operations

Although all practicable safety devices are provided, such as controls, recording thermometer, and flow diversion valve, the most important factor is the human element. The operator and his supervisor should thoroughly understand and check the operation in detail, because the safety and quality of the product depend on constant vigilance in the entire pasteurization operation as outlined in section G.

The *heat exchange surfaces* are critical areas in any cleaning program. Because of the temperatures required, a thin layer of egg solids may adhere to these surfaces. Cleaning-in-place (CIP) is not always adequate. Visual inspection of the heat transfer surface, or some other method of checking the adequacy of cleaning, is necessary after each run. While an inspection for cleaning is being made the heat transfer surfaces should also be checked for any evidence of etching or porosity development. Corrosion may result from incomplete cleaning or excessive use of acid or chlorine in sanitizing operations (sections E.3.2.1, G.3.4. and G.3.5).

A drain in the separate filling room should be avoided as it has been determined that it will breathe contaminated air from the drain into the filling room whenever there is a flooding of other drains from cleanup operations (*24*). Providing floor drainage to an outside room can correct this source of airborne contamination.

A frequent cause of recontamination is that personnel who have been handling raw products later handle containers or equipment for pasteurized products. Even where they only pass through the room in which filling is taking place, the air movement over their clothes, spattered or contacted by raw product in limited areas, may create aerosol that could contaminate open containers of pasteurized product nearby. Those who fill, handle, or prepare pasteurized egg containers or storage tanks should not handle the raw product, its containers, tanks, or other equipment unless they change their outer clothing and wash their hands after such contact with raw product, containers, or equipment.

Pasteurized product containers shall be clean and sanitary (section J.4), and they should not be exposed to airborne contamination or contamination by manual handling during transfer and storage. Nested tapered cans handled in plastic film-covered bundles of 12 each, or the heavy paper-covered packages of 12 straight-sided cans in a package offer excellent protection. Clean and sanitary containers can be obtained as single clean commercially sterile pre-lidded cans if properly stored and handled or by the proper operation of a can washer.

Air for processing dried egg products presents a special problem. Salmonellae have been found occasionally in samples of dried milk where they have not been found in the pasteurized liquid milk before drying. Salmonellae have been found in bird droppings and on parts of roofs adjacent to air intakes for drying plants. Frequently, the heating and flow of the intake air in the drier is not sufficiently uniform to assure destruction of salmonellae, if present. The air-intake opening should be located an appreciable distance (such as 6 feet) away from the roof, ledges, or walls that birds might frequent. In this way, the drawing in of air over surfaces contaminated by birds would be minimized. In addition it must be filtered to eliminate dust and other airborne contaminants (see section J.6). A regular program of air-filter change (often daily) must be followed to maintain efficiency. The air discharge should be as remote from the intake as practicable. The air intakes and discharge openings of the drier should be automatically closed during shutdown.

APPENDIX 1

USDA ACCEPTED PRACTICES FOR THE SANITARY CONSTRUCTION, INSTALLATION, TESTING AND OPERATION OF HIGH-TEMPERATURE SHORT-TIME (HTST) LIQUID EGG PASTEURIZERS

CONTENTS OF APPENDIX 1

These accepted practices for HTST pasteurizers for liquid egg and egg products use the basic provisions of the 3A Accepted Practices for the Sanitary Construction, Installation, Testing, and Operation of High-Temperature Short-Time (HTST) Pasteurizers (see Appendix 2, Item 13) developed for milk and dairy products. These are modified as needed to cover liquid eggs and egg products. In the development of this manual it was not the intention to limit the opportunity for invention or new developments. If a manufacturer or fabricator develops a high-temperature short-time method and apparatus different in design, material, construction, installation, operating procedure, or otherwise from the practices discussed in the following sections, and if, in his opinion, his method is equivalent or better, he may submit his specifications at any time for consideration.

These accepted practices were developed to provide processors, manufacturers, and controlling inspection agencies with specifications for the proper construction, installation, and operation of new high-temperature short-time pasteurizers for liquid eggs and egg products.

While this Appendix may be of interest to all egg processing plants, special consideration has been given to operation of plants under the USDA Grading and Inspection Service. Items applying *only* to plants under State or local inspection are assembled in section K.

A. SCOPE

These Accepted Practices shall pertain to high-temperature short-time (HTST) pasteurization equipment, appurtenances, and controls used in a complete processing system for liquid eggs or egg products. In addition to pasteurization, such systems may include clarification, filtration, homogenization, and all processes that may influence proper time, pressure, and temperature relationships. To conform with these Accepted Practices, HTST pasteurizers shall comply with the following design, material, construction, and installation criteria.

B. DEFINITIONS.

B.1

HTST Pasteurization is a continuous process consisting of (a) rapidly heating every particle of liquid eggs (whole eggs, whites, plain yolks, and mixtures with sugar, salt, or other materials, including some chemicals that aid pasteurization) to a temperature ranging from 125° to 150° F. or higher; (b) holding the product at the specified temperature for times generally ranging up to 10 minutes as required for the specific product; and (c) rapidly cooling the product.

B.2

Product Contact Surfaces shall mean all surfaces exposed to the product and surfaces from which liquid may drain, drop, or be drawn into the product.

B.3

Nonproduct Contact Surfaces shall mean all other exposed surfaces.

C. COMPONENTS.

The HTST Pasteurizer shall consist of the following:

C.1

Component Equipment.

C.1.1

Raw product constant-level tank.

C.1.2

Heating and cooling equipment involving:

C.1.2.1

Regenerative section (when desired). The HTST pasteurizer may omit a regenerative section or it may be in a separate unit.

C.1.2.2

Heating section(s).

C.1.2.3

Cooling section(s) (when desired). The heating section and cooling section may be in separate units. Also, a water cooling section before final cooling may be used.

C.1.2.4

Press (or frame) for one or more of these sections.

C.1.3

Timing pump.

C.1.4

Holding tube.

C.1.5

Flow-diversion valve with recorder-controller.

C.1.6

Temperature controller.

C.1.7

Indicating thermometers.

C.1.8

Connecting sanitary pipe and fittings.

C.1.9

Heating medium system.

C.1.10

Cooling medium system (when a cooling section(s) is included).

C.2

Optional Component Equipment.
Certain product processes synchronize well with the HTST pasteurizer; therefore, the necessary equipment and associated controls may be connected as part of the complete HTST system.

C.2.1
Control panel.

C.2.2
Product booster pump.

C.2.3
Homogenizer (or high-pressure pump).

C.2.4
Clarifier.

C.2.5
Filter.

C.2.6
Drawoff tank.

C.2.7
Auxiliary pumps.

C.2.8
Other processing equipment or component parts.

D. MATERIALS FOR PRODUCT CONTACT SURFACES.

D.1

Materials for which Standards or Accepted Practices Exist.
The materials of product contact surfaces of component equipment, or optional component equipment for which there are 3-A Sanitary Standards or Accepted Practices shall comply with the material criteria of the applicable Standards or Accepted Practices (see Appendix 2).

D.2

Other Materials.
All other product contact surfaces shall be stainless steel of the AISI 300 series[4] or the corresponding ACI[5] types (see section I) or other equally corrosion-resistant metal that is nontoxic and nonabsorbent, or heat-resistant glass, except materials given in sections D.2.1 to D.2.3.

[4]/ The data for this series are contained in the following references: AISI Steel Products Manual, Stainless and Heat Resistant Steels, April 1963, table 2-1, pp. 16-17. Available from American Iron and Steel Institute, 633 Third Avenue, New York, N. Y. 10017.

[5]/ A.C.I. Standard Designations and Chemical Composition Ranges for Heat and Corrosion Resistant Castings. Alloy Casting Institute, 300 Madison Avenue, New York, N. Y. 10017.

D.2.1
Single service gaskets may be used.

D.2.2
Rubber and rubberlike materials may be used in sealing applications. These materials shall comply with the applicable provisions of 3-A Sanitary Standards (Appendix 2, Item 9).

D.2.3
Plastic materials may be used in sealing applications. These materials shall comply with the applicable provisions of 3-A Sanitary Standards (Appendix 2, Item 10).

E. CONSTRUCTION (FABRICATION).

E.1

Surface Finish, Internal Angles, Cleanability.

E.1.1
The fabrication criteria of component or optional component equipment for which there are 3-A Sanitary Standards or Accepted Practices shall be those of the applicable standards or accepted practices.

E.1.2
All other component equipment or optional component equipment shall conform to the fabrication criteria given in sections E.1.2.1 to E.1.2.4.

E.1.2.1
All product contact surfaces shall be at least as smooth as a No. 4 mill finish on stainless steel sheets. Surface finish equal to 150 grit or better as obtained with silicon carbide is considered acceptable.

E.1.2.2
Appurtenances having product contact surfaces shall be cleanable, either when in an assembled position or when disassembled, and be so designed as to facilitate adequate inspection. Removable parts shall be readily demountable.

E.1.2.3
All internal angles of 135° or less on product contact surfaces shall have minimum radii of one-fourth inch except where smaller radii are required for essential functional reasons.

E.1.2.4
Nonproduct contact surfaces shall have a smooth finish, be free of pockets and crevices, and be readily cleanable.

E.2

Raw Product Constant-Level Tank.

E.2.1
The tank shall be of such design and capacity that air will not be drawn into the pasteurizer with the

product when the tank is operating at maximum sealed capacity of timing pump or timing device.

E.2.2

The tank shall be fitted with a removable cover having overlapping edges turned down at least one-half inch below the top edge of the tank. The cover shall be pitched on an outside edge(s) so as to be free draining and shall be provided with handle(s) of sanitary design. When the tank is 18 inches or more in diameter, or more than 2 square feet in cross-section area, the cover shall be provided with an inspection port or opening at least 4 inches in diameter and fitted with its own overlapping cover. All openings in the cover, to which connections are not permanently attached, shall be flanged upward at least three-eighths inch, and shall be not more than one-fourth inch larger in diameter than the entering sanitary pipe or appurtenance. All sanitary pipelines and other appurtenances entering through the cover, and not permanently attached to the cover, shall be fitted with a sanitary umbrella deflector that overlaps the edges of the opening through the cover and is located as close to the cover as is practical.

E.2.3

The tank may be equipped with an automatic device of sanitary construction to control the raw product level.

E.2.4

The tank bottom shall be pitched to the outlet at least one-fourth inch per foot. The top of the terminal end of the outlet passage shall be lower than the low point of the tank bottom at the outlet.

E.2.5

All pipeline connections shall conform to 3-A Sanitary Standards (Appendix 2, Item 4).

E.3

Heating and Cooling Equipment.

E.3.1

The product heating and cooling equipment shall conform in all details to 3-A Sanitary Standards (Appendix 2, Items 6 and 7).

E.3.2

When a regeneration section is employed in a product heat exchanger, it shall be so constructed and operated that there can be no leakage from the raw to the pasteurized egg passages. The general requirement for operation is that the pressure on the pasteurized side of the plates or tubes shall be higher than on the raw side. The pasteurizer should include an automatic control system that insures a higher pasteurized than raw product pressure in the regenerator during the pasteurization run. This will positively prevent leakage from raw to pasteurized product in case any plate is defective.

E.3.2.1

In USDA plants operating under continuous inspection the requirement for a higher pressure on the pasteurized side of regenerator sections has not been required in the past. In these plants the USDA Resident Inspector carefully inspected **all** regenerator sections not only for cleanliness but also for evidence of etching, corrosion, or cracking of the metal that might eventually lead to a point of leakage. Any suspected sections were replaced. The practice of allowing a lower pressure on the pasteurized-product side of the regenerator plates or tubes may not be continued.

E.4

Timing Pump.

E.4.1

The timing pump shall be of the positive displacement type, and shall conform to 3-A Sanitary Standards (Appendix 2, Items 2 and 3).

E.4.2

The timing pump shall have its driving mechanism so designed that in case of wear, belt stretch, or any other condition affecting the capacity of the pump, the capacity will not increase. The pump capacity should always be checked for each product run.

E.4.3

Variable and fixed capacity driving mechanisms are permitted.

E.5

Holding Tube.

E.5.1

The holding tube, including its inlet and outlet connections, shall be constructed of sanitary pipe and fittings that conform to 3-A Sanitary Standards (Appendix 2, Items 4 and 12), except that fully welded holding tubes are not permitted.

E.5.2

The holding tube shall be designed to provide for the holding of liquid eggs at the required temperature for the minimum required holding time at the maximum rate of flow. The product in the holding tube should be under sufficient pressure (20 p.s.i. minimum is suggested) to prevent the release of any air incorporated in the product.

E.5.3

The holding tube should be jacketed or insulated to maintain temperature, but it must not be used to raise the product temperature in the holder tube.

E.5.4

Changes in the length of holding tube to compensate for changes in rate of product flow are not permitted.

E.5.5

The holding tube shall be designed to have a continously upward slope, in the direction of flow, of not less than one-fourth inch per foot.

E.5.5.1

Any connection to the inlet or any part of the holding tube that has less than one-fourth inch per foot upward slope shall not be considered part of the holding tube.

E.5.5.2

Supports for tubes shall be provided to maintain all parts of the holding tube in a fixed position free from any movement laterally or vertically.

E.5.6

The holding tube shall be provided with fittings for the following: indicating thermometers at the inlet and outlet end of the tube and the temperature sensor of a recorder-controller upstream from the inlet of the flow diversion device. The distance unpstream shall be sufficient to prevent forward flow of unpasteurized product during a diversion. The device shall include a time-delay relay to prevent premature forward flow. The holding tube between the sensor and the divert device shall be insulated.

E.6

Flow-Diversion Device With Recorder-Controller (detailed specifications).

E.6.1

The flow-diversion device, and inlet and outlet connections thereto, shall be constructed to conform to 3-A Sanitary Standards (Appendix 2, Item 4).

E.6.2

The flow-diversion device shall be so designed that when in diverted-flow position, product cannot pass into the forward flow line. To make certain of this, the device shall meet the following requirements:

E.6.2.1

A leak escape shall be installed on the forward flow side of the valve seat. When back pressure is exerted on the forward-flow side of the valve seat, while the product flow is being diverted, the leak escape should lie between two valve seats, or between two parts of the same seat, one upstream and the other downstream from the leak escape. The leak escape shall be so designed and the valve so installed as to drain all leakage to the outside. The leak escape shall be designed with one or more openings, with a total effective open area of at least 5/32-inch diameter. Openings of this small size require close attention and cleaning to prevent plugging. On new installations, new-type flow diversion valves with a minimum 1.402-inch inside diameter leaker opening should be provided.

E.6.2.2

The closure of the forward-flow seat shall be sufficiently tight so that leakage does not occur past it, as evidenced when the forward-flow line is disconnected; and in order that proper seating may not be disturbed, the length of the connecting rod shall not be adjustable by the user.

E.6.2.3

It shall be impossible to tighten the stem packing to such an extent as to prevent the valve from assuming the fully diverted flow position.

E.6.2.4

The flow-diversion device shall be actuated by the same temperature sensor that actuates the product temperature recorder.

E.6.3

The flow-diversion device shall include means that will automatically cause diversion of the product flow when the product leaving the holding tube is at less than the required minimum pasteurizing temperature.

E.6.3.1

The flow-diversion device shall move from the forward to fully diverted flow position in not more than 1 second after the moment of power cutout during descending temperatures.

E.6.4

The flow-diversion device shall include means, when the product is at sub-legal temperature, that will automatically de-energize the timing pump until the flow-diversion device reaches its fully diverted position (Section F.5.3).

E.6.5

The flow-diversion device shall provide means for automatically returning the product to forward flow when the product has been restored to the required minimum pasteurizing temperature.

E.6.6

The flow-diversion device shall provide means that will automatically cause diversion of the product flow in case of actuating power failure.

E.6.7

The recorder-controller, with its temperature sensor located in accordance with Section E.5.7, shall meet the following requirements:

E.6.7.1

Case—moisture-proof (under operating conditions encountered in pasteurization plants).

E.6.7.2

Scale range—span not less than 30° F. including 12° above and below the diversion temperatures.

E.6.7.3

Temperature accuracy ± 1° F. at the diversion temperatures.

E.6.7.4

Power operated—all recorder-controller clocks shall be electrically (not spring) operated.

E.6.7.5

Temperature represented by smallest temperature-scale division—1° F. over specified scale range.

E.6.7.6

Spacing of 1°F. scale division—not less than one-sixteenth inch at the diversion temperature plus and minus 1°.

E.6.7.7

Time represented by smallest time-scale division —not more than 15 minutes.

E.6.7.8

Equivalent 15-minute chord or straight-line length —not less than one-fourth inch at the diversion temperature, plus and minus 1° F.

E.6.7.9

Pen-arm setting device—easily accessible, simple to adjust.

E.6.7.10

Pen and chart paper—designed to give line not over 1/40-inch thick when in proper adjustment, which shall be easy to maintain.

E.6.7.11

Temperature sensor—protected against damage at temperatures up to 200° F.

E.6.7.12

Stem fitting or bulb—shall conform to 3-A Sanitary Standards (Appendix 2, Item 5).

E.6.7.13

Chart speed—a circular chart shall make one revolution in not more than 12 hours and shall be graduated for a maximum record of 12 hours. Additional charts shall be used if operations extend beyond 12 hours. Strip charts may show a continuous recording.

E.6.7.14

The recorder-controller shall be provided with an additional pen-arm for recording upon the outer edge of the chart the full record of the time during which the flow-diversion device is in the forward-flow and the diverted-flow positions. The temperature-recording pen shall be synchronized with the chart time divisions. The diversion pen shall be synchronized with the chart time when in diverted flow.

A dual diversion point recorder-controller is suitable for controlling and recording the required different temperatures of *two* kinds of products. Such controllers are provided with two separate diversion points, one for each of two products. The control can also be wired through the control terminal box to a two-speed pump motor where two different flow rates are desirable. The new models of dual diversion point recorder-controller are equipped with a third pen that draws a line on the chart to show the temperature at which the flow diversion valve is set. Old models can be modified by the manufacturer to record the flow diversion setting as above described.

When a pasteurizer must operate at several temperatures a multidiversion point unit should be used. An existing single diversion point recorder-controller may be modified by the manufacturer to a multidiversion-point unit. The diversion point temperature can be set by the operator to comply with requirements for the product being pasteurized. The units shall include a pen to continuously record the flow diversion point setting on the chart with a line that is distinguishable from the line showing the temperature of the product at the holder outlet. This type of recorder-controller will show the following record of the pasteurized operation for ***each*** product:

(1) The temperature of the product at the outlet of the pasteurizer holder.
(2) The temperature of the flow diversion valve setting.
(3) The time that the flow diversion valve is in the forward and diverted (if any) flow.
(4) The operator's notes showing the points of starting and stopping each product and name of the product.

E.6.7.15

Thermometric response—with the recorder-controller temperature sensor at room temperature and then immersed in a well-stirred waterbath (or can) at 7° F. above the cut-in temperature, the interval between the moment when the recording thermometer reads 12° below the cut-in temperature and the moment of power cut-in shall not be more than 5 seconds.

(PRECAUTION: The can should be so placed that when the temperature sensor is immersed it will be approximately at its normal operating elevation. This will avoid errors due to the hydrostatic effect within the tube system or thermal element.)

E.6.7.16

The cut-in and cut-out response shall be independent of the temperature-recording pen-arm movement.

E.7

Temperature Controller—Hot Products.

E.7.1

Each HTST pasteurizer shall be equipped with a dependable automatic temperature control system designed so that the final heated product temperature can be accurately maintained.

E.7.2

The temperature control system shall be designed to cut off the flow of the heating medium when the actuating power fails.

E.8

Indicating Thermometers—Hot and Cold Products.

E.8.1

Hot product thermometers (two required, located as per Section E.5.7).

E.8.1.1

Type—mercury-actuated; direct reading; contained in corrosion-resistant case that protects against breakage and permits easy observation of column and scale; filling above mercury, nitrogen, or equally suitable gas.

E.8.1.2

Magnification of mercury column— to apparent width not less than one-sixteenth of an inch.

E.8.1.3

Scale—span not less than 25° F. including the pasteurizing temperatures, plus and minus 5° graduated in 0.5° divisions with not more than 8° per inch of scale. The thermometer should be protected against damage at 220°. *(Note:* The above thermometer will cover the current liquid egg products pasteurizing temperatures of 125°, 134°, 140°, 142°, and 146°.) It also includes the sanitizing temperature of 170° (see Section G.2.4). This thermometer provides a scale with 1/8-inch per degree (1/16-inch per half degree marking) which is four times more readable and accurate than the present scale of 1/16-inch per 2°.

E.8.1.4

Accuracy—within 0.5° F., plus and minus, throughout specified scale range.

E.8.1.5

Stem fittings—pressure-tight against inside wall of fittings; no threads exposed to product; distance from under side of ferrule to end of bulb not less than 3 inches. Pipeline connection to be in accordance with 3-A Sanitary Standards (Appendix 2, Item 5).

E.8.1.6

Thermometric response—when the thermometer is at room temperature and then is immersed in a well-stirred water bath 19° or less above pasteurization temperature, the time required for the reading to increase from water-bath temperature minus 19° to water bath temperature minus 7° shall not exceed 4 seconds.

E.8.1.7

Bulb—Corning normal or equally suitable thermometric glass.

E.8.2

Cold product thermometer (recommended location, see Section F.7.2).

E.8.2.1

Type—same as hot product (Sec. E.8.1.1).

E.8.2.2

Magnification of mercury column—same as hot product (Sec. E.8.1.2).

E.8.2.3

Scale—range 30° to 100° F., with extension on either side permitted; protection against damage at temperature up to 220°; graduated in 1° divisions, with not more than 22 divisions per inch of scale.

E.8.2.4

Accuracy—within 1° F. plus and minus throughout specified scale range.

E.8.2.5

Stem fittings—same as hot product (Sec. E.8.1.5).

E.8.2.6

Bulb—Corning normal or equally suitable thermometric glass.

E.8.2.7

Alternate-type thermometer—a dial-type thermometer that conforms to the functional and constructional requirements of the general specification of mercury-in-glass cold product line thermometers shall be acceptable.

E.9

Connecting Sanitary Pipe and Fittings

E.9.1

All connections to and between the parts of the pasteurizer shall be made with fittings and piping conforming to 3-A Sanitary Standards (Appendix 2, Items 4 and 12).

E.9.2

A bypass valve(s) may be provided in the pasteurized product discharge line down stream from the vacuum breaker for bypassing rinse water, cleaning solution, or sanitizing solution during start-up, shut-down, or clean-up, or for the recirculation of pasteurized product.

If a bypass valve(s) is used, a separate self-draining sanitary pipeline shall be provided from the bypass valve(s) directly to the raw product constant-level tank and be so designed as to preclude back siphonage.

E.9.3

A sanitary pipeline shall be provided from the diversion connection of the flow-diversion device to the raw-product constant-level tank, or to waste. If the diverted flow line returns to the raw-product constant-level tank, it shall enter the top of the tank or side of the tank above the maximum normal product level and shall be self-draining. The diverted flow line shall be free of restrictions unless such restrictions are so designed that stoppage of the diversion line cannot occur. If necessary to lengthen the time in the holder during diverted flow, an identifiable self-draining restriction may be put in a vertical portion of the diverted flow line.

E.10

Heating Medium System.

Any means, such as hot water, steam, electricity, or regeneration, may be used to tranfer heat to the product, provided it is applied in such a manner as not to contaminate the product (Sections E.3 and E.7).

E.11

Cooling Medium System.

E.11.1

Any means, such as water, brine, nontoxic antifreeze solutions, regeneration, or "direct expansion" may be used to transfer heat from the product, provided it is applied in such a manner as not to contaminate the product. An indicating thermometer should be provided to show the temperature of the cooling medium as it goes to the cooling section.

E.11.2

The cooling medium system, including the supply storage tank, shall be designed to prevent contamination of the medium.

E.11.3

If the temperature of the cooling medium is lower than the freezing temperature of the product, a means to provide automatic control of the temperature or flow of the cooling medium or both to prevent freezing of the product is desirable.

E.12

Control Panel.

A control panel should be readily accessible to the pasteurizer operator.

E.12.1

Mounting of components described in this section (E.12.1) in or close to the control panel is desirable.

E.12.1.1

An electric clock, provided with at least a 6-inch dial face, and a sweep hand the full radius of the clock face.

E.12.1.2

Recorder-controller.

E.12.1.3

Temperature-controller—hot products.

E.12.1.4

Remote-control type of motor switches wired for proper operation for each motor involved in the HTST assembly. Each switch shall be plainly labeled with the name of the component served.

E.12.2

When installed complete in the product pasteurizing room the panel shall have a door or easily removable cover for access.

E.13

Product Booster Pump.

E.13.1

A product booster pump may be used to supplement the timing pump. This pump may be either a rotary or centrifugal type. When two positive pumps are used, extreme care must be taken to match capacities in operation by use of an accurate gage to maintain an adequate pressure on the inlet of the second pump—and further to avoid foam or functional damage or both if a centrifugal pump is used.

E.13.2

Such pumps, if used, shall conform to 3-A Sanitary Standards (Appendix 2, Item 2).

E.14

Homogenizer.

E.14.1

When a homogenizer is installed and operated in conjunction with an HTST pasteurizer, it shall conform with 3-A Sanitary Standards (Appendix 2, Item 3).

E.14.2

The homogenizer shall be installed so that it will not reduce the holding time below the required minimum.

E.15

Pasteurized Product Drawoff Tank.

E.15.1

When a filling machine is used, a pasteurized product drawoff tank should be provided to prevent frequent shutdowns.

E.15.2

The drawoff tank shall conform with the applicable provisions of 3-A Standards (Appendix 2, Items 1, 8, 11).

E.15.3

The drawoff tank should have a capacity equivalent to 15 or more minutes of run of the HTST pasteurizer at maximum capacity. Customarily two tanks are used in the peroxide process.

E.16

Auxiliary Alarm System for Peroxide Process.

An alarm system is required to assure that the required flow rate of peroxide solution is maintained. A rotometer with an adjustable sensing coil can be used to indicate that the flow rate from the peroxide pump is within the required limits. The rotometer coil should be electrically or pneumatically (or both) connected to the flow diversion valve and an alarm bell so that these operate if the peroxide flow rate drops below the required minimum setting. If the peroxide pump is of a type that gives a pulsing flow rate, an air chamber in the line from the pump to the rotometer is required for proper operation of the rotometer.

E.17

Accessory Processing Systems.

The equipment of any accessory processing system, integrated into an HTST pasteurizer, shall meet the applicable provisions of these Accepted Practices and any applicable 3-A Sanitary Standards and Practices.

F. INSTALLATION (COMPONENT PARTS).

All component equipment or optional component equipment, except heating and cooling equipment, shall be connected to each other with sanitary pipelines and fittings and shall be properly installed so as not to have any adverse effects on the time, temperature, and pressure relationships of the HTST system. Such parts and equipment shall be installed to facilitate easy access for cleaning, maintenance, and inspection.

F.1

Raw Product Constant-Level Tank.

F.1.1

The constant-level tank shall be installed so that all the contents will drain to the outlet before the outlet becomes uncovered.

F.1.2

The tank shall be installed so that its top rim is always lower than the lowest product level in the regenerator.

F.2

Heating and Cooling Equipment.

When a plate-type heat exchanger is installed, the processor shall have available for the inspection agency a diagram showing the plate and porting arrangement in proper operating sequence.

F.3

Timing Pump or Timing Device.

The driving motor and starter shall be interwired with all components, as prescribed in section F.5.

F.4

Holding Tube.

The holding tube supports shall be installed and adjusted to maintain all parts of the holding tube in a fixed position and to maintain the minimum upward slope, as prescribed in section E.5.5.

F.5

Flow-Diversion Device with Recorder-Controller.

F.5.1

The temperature sensor of the recorder-controller shall be installed in the connection for same, as described in section E.5.6.

F.5.2

The flow-diversion device shall be so interconnected with the recorder-controller that the flow-diversion device automatically assumes the diverted and forward-flow positions, respectively, when the temperature is below and above the required temperature. However, during circulation of cleaning solution, the flow-diversion device may assume the forward flow position or be cycled at less than the required pasteurizing temperature. The control required to do this must be a programmed control that is fail-safe and is interlocked with the timing pump so that the timing pump cannot run under this condition.

F.5.3

The timing pump shall be interwired with the flow-diversion device and the recorder-controller so that the timing pump cannot run at sub-legal temperature, unless the flow diversion device is in its fully diverted position.

F.6

Temperature-Controller—Hot Product.

This shall be installed as part of the heating medium system.

F.7

Indicating Thermometers.

F.7.1

Indicating thermometers—hot products.

These shall be installed in the fittings at the inlet and outlet end of the holding tube, as described in section E.5.6.

F.7.2

Indicating thermometer—cold product.

This shall be installed in the pipeline from the outlet of the cooling section and close to the pasteurizer.

F.8

Connecting Sanitary Pipe and Fittings.

Sanitary pipelines connecting components of an HTST pasteurizer shall be without dead ends, except for openings on sanitary fittings.

F.9

Heating Medium System.

F.9.1

When the heating medium system is not integral with other components of the pasteurizer, it can be installed outside the product-processing room.

F.9.2

Sanitary piping is not required for connecting the heating medium unit with the heating section of the pasteurizer. However, when a plate-type heat exchanger is used, the piping shall not prevent movement of the plates.

F.9.3

Water supply to the heating system shall be protected against backflow by an airgap of not less than two diameters (nominal pipe size), with a minimum of 1 inch, or other effective backflow preventive device.

F.10

Cooling Medium System.

F.10.1

The equipment used in recooling and recirculating the cooling medium shall be installed, whenever practical, outside the product processing rooms.

F.10.2

Sanitary piping is not required for connecting the cooling medium unit with the cooling section of the pasteurizer. However, when a plate-type heat exchanger is used, the piping shall not prevent movement of the plates.

F.10.3

Water supply to the cooling medium system shall be protected against backflow by an airgap of not less than two diameters (nominal pipe size), with a minimum of 1 inch, or other effective backflow preventive device.

F.10.4

Where recirculated cooling medium is used, it should be properly protected from contamination.

F.11

Control Panel.

F.11.1

The control panel shall be readily accessible to the HTST pasteurizer operator.

F.11.2

The control panel shall be supported so that vibration is minimized.

F.11.3

Control devices shall be interwired or piped with all Component Equipment or Optional Component Equipment, so as to facilitate their operation from a general central point.

F.12

Clarifier.

F.12.1

When a clarifier is used in an HTST system, it shall be spaced to provide adequate access for cleaning.

F.12.2

The clarifier shall have the driving motor wired independently of the timing pump and flow-diversion device, so that if the timing pump is stopped, the clarifier can continue to run.

(Note: The clarifier will not produce flow.)

F.12.3

A magnetic starter, with set interlock contacts (single phase), should be wired with the timing pump electrical circuit, so that in case the clarifier stops (through fuse blowout) the timing pump will also stop.

F.13

Pasteurized Product Drawoff Tank.

If provided, the pasteurized product drawoff tank shall be installed downstream from the outlet of the cooling section of the HTST pasteurizer.

F.14

Auxiliary Pump.

When an auxiliary pump(s) is used in an HTST pasteurizer system, it must be installed and operated in such a way that it will not interfere with the detection or stoppage of the forward flow of unpasteurized product, and reduce the holding time below the required minimum.

F.15

Electric Wiring.

All electric wiring interconnection should be in permanent conduit (except that rubber-covered cable may be used for final connections), in accordance with the local electrical code, with no electrical connections to defeat the purpose of any provision of the Practices.

F.16

Checking and Testing Before Final Testing by the Control Authority.

F.16.1

Completed installation shall be thoroughly checked and tested by a qualified representative of the manufacturer, his distributor, or the processor, to determine that the installation meets all provisions of these Accepted Practices. The qualified representative is one who shall have had special instruction under the supervision of a qualified person on HTST pasteurizing systems, and who has made or supervised two actual complete installations that have been approved.

F.16.2

The recorder-controller, flow-diversion device, indicating thermometer, temperature control, and other parts shall be made to function within the limits of requirements of these Accepted Practices. The following tests shall be made, in accordance with either the methods prescribed in Procedures For Testing Pasteurization Equipment (*16*), or if no test is prescribed, with the criteria in these USDA Accepted Practices. (In the following listing, test numbers and page numbers refer to reference *16*.)

TESTS OF INSTRUMENTS AND EQUIPMENT

1. Indicating Thermometers:
   Temperature accuracy (Test No. 1, p. 7).
   Thermometric response (Test No. 7, p. 8).
2. Recorder-Controller:
   Temperature accuracy (Test No. 2, p. 9).
   Time accuracy (Test No. 3, p. 10).
   Check against indicating thermometer (Test No. 4, p. 9).
   Thermometric response (Test No. 8, p. 12).
   Cut in and cut out (Test No. 10, p. 11).
3. Flow Diversion Valve—Proper Assembly and Function:
   Leakage past valve seat (Test No. 5A, p. 13).
   Leak escape operating properly (section E. 6.2.1).
   Operation of valve stem (Test No. 5B, p. 14).
   Valve assembly (Test No. 5C, p. 14).
   Manual diversion (Test No. 5D, p. 15).
   Response time (Test No. 5E, p. 16).
4. Continuous Flow Holder (holder tube):
   Holding time. *(Note:* The holding time test shall conform with section H "Determination of Holding Time.")
5. Temperature Control:
   Maintenance of heating medium temperature (Sec. E.7.1).
   Cutoff of heating medium (Sec. E.7.2).

G. OPERATION.

G.1

Personnel.

A person assigned the responsibility of operating and cleaning any HTST pasteurizer must be adequately trained.

G.2

Sanitizing Treatment—Hot Water Method.

G.2.1

About 30 minutes before product pasteurization is to begin, close the heating and cooling equipment and connect all Component Equipment, including Optional Component Equipment assembled in the system, with Connecting Sanitary Pipe and Fittings, as is necessary for pasteurizing. Arrange the bypass line and the bypass valve(s) at the pasteurizer outlet to discharge into the raw-product constant-level tank.

(Note: To save wear on the timing pump, a separate centrifugal circulating pump can be used to produce flow during CIP (cleaning in place). The timing pump should be connected in system in its normal position but with a bypass between its outlet anl inlet.)

G.2.2

Introduce potable water to the raw product constant-level tank, start the timing pump (or the substituted circulating pump), and continue to introduce water until the system is full.

G.2.3

Start the circulation of the heating medium system, and set its temperature control at 175° F. or higher. Do not turn on the cooling medium system.

G.2.4

When the circulating water reaches 170° F. or higher in the raw product constant-level tank, allow it to continue to circulate for at least 5 minutes. Sanitize the timing pump and diversion line by circulating 170° or higher water. Discharge water from the pasteurizer outlet to waste through the bypass line. The cover of the raw-product contant-level tank, surge tank, other parts, and sanitary lines not sanitized by hot-water circulation with the pasteurizer, shall be independently sanitized.

G.2.5

Shut down the timing pump (or the substituted circulating pump). If a substituted circulating pump is used, remove it from the assembly and also the bypass line around the timing pump.

G.3

Sanitizing Treatment—Chemical Method (Chlorine).

G.3.1

About 30 minutes before pasteurization is to begin, close the heating and cooling equipment and connect all Component Equipment, including Optional Component Equipment assembled in the system, with Connecting Sanitary Pine and Fittings, as is necessary for pasteurizing. Arrange the bypass line and the bypass valve(s) at the pasteurizer outlet to discharge into the raw-product constant-level tank.

G.3.2

Introduce potable water to the raw-product constant-level tank, start the timing pump, and continue to introduce water until the system is full.

G.3.3

Start the heating-medium system and set the temperature to attain forward flow. Do not turn on the cooling-medium system. It may be necessary to add water when the system assumes forward flow, to maintain level above the outlet of the raw-product constant-level tank.

G.3.4

After bringing the water being circulated in place of product up to pasteurizing temperature, the operator should *slowly* introduce a hypochlorite compound, or other chemical sanitizer approved by the control authority, into the raw-product constant-level tank in sufficient quantity to provide required concentration. A minimum of 50 p.p.m. of chlorine at the outlet at a temperature of at least 75° F. is required.

(Note: Care must be exercised in selecting a hypochlorite or other chemical sanitizer that will not be injurious to metallic or nonmetallic parts in the system. Excessive temperature, exposure time, and concentrations may be injurious to such parts. Concentrated solutions should never be placed in raw-product constant-level tank until water is present. Dry ingredients should be predissolved. Instead of introducing water and a chemical sanitizer into the raw-product constant-level tank, a prepared chemical sanitizing solution of proper strength can preferably be introduced into this tank.)

Continue circulation for 2 minutes or more in forward flow. The circulation of hot chlorine solution should not exceed 15 minutes to avoid the possibility of corrosion. The flow-diversion line should also be adequately sanitized. Change the bypass line to discharge to waste. Shut down the timing pump. The unit should then be put into operation on the egg product promptly. If an emergency arises that prevents introduction of product, the unit should be flushed with potable water to prevent corrosion. Resanitizing is required before pasteurization is initiated.

G.3.5

The cover of the raw-product constant-level tank, drawoff tank, or other parts and sanitary lines not sanitized with the pasteurizer should be independently sanitized. Surfaces of such equipment that will not be in contact with product should be rinsed free of chlorine sanitizer with potable water to prevent corrosion.

G.4

Starting Product Immediately After Sanitizing.

G.4.1

Reset the temperature control to provide the required minimum pasteurizing temperature for the product.

G.4.2

Start the timing pump. When the water in the raw-product constant-level tank has been lowered to the level of its outlet, admit product. The volume of water and diluted product to be drawn off at the pasteurizer outlet should be determined at the time of initial operation by comparison of the discharged product with the infeed raw product, and with use of suitable laboratory procedures.

G.4.3

The cooling medium system should be turned on in advance to assure that the cooling section is at the proper temperature.

(WARNING: If the temperature of the cooling medium is lower than the freezing temperature of the product, care should be exercised to prevent freezing of the product.)

G.4.4

Safety controls are automatic. If the product temperature is less than required when it reaches the temperature sensor of the recorder-controller, it will automatically be returned to be reheated. Controls are such that they will automatically cause the flow-diversion device to go into the forward-flow position when the product reaches required temperature.

G.5

Running Product and Product Changeover.

Before starting the day's operation, adjust the recorder-controller chart so that the temperature pen correctly indicates the time of day. Promptly after starting, and throughout the run, operator should make such readings of thermometers and notations on the recorder-controller chart as are required by the inspection agency. As a minimum the operator should include the following information on the chart:

Company name. Date. Operator's signature or initials. Name of product pasteurized. Indicating-thermometer reading during the pasteurization period referenced to the pen line at the time of thermometer reading. Cut-in and cut-out temperatures of the flow-diversion valve determined during sanitizing or at the beginning of each day's operation.

G.5.1

Products that do not materially affect one another may follow one another through the pasteurizer, without intermediate rinsing or sanitizing treatment New product should not be introduced into the raw-product constant-level tank until the level of all previous product has been reduced to a practical minimum. This may be accomplished by either manual or automatic controls.

G.5.2

The output of the pasteurizer may be decreased within the range and below the top speed of the variable-speed drive of the timing pump. Heavy-bodied products, such as yolks, will require lower flow rates to keep operating pressure within limits, as well as to provide a greater ratio of heating surface to product, because of greater difficulty in heating due to the increased viscosity. Rate of flow of product should be measured by determining the time for a weight of product to be discharged under operating conditions. This determination should be recorded for each run and for each change of product. The weight of each product pasteurized should be recorded also.

G.5.3

Where specific products require higher minimum pasteurization temperatures, as indicated in table 6, such temperatures should be established just before the changeover.

G.5.4

An HTST pasteurizer can be used to pasteurize egg and egg products that require different temperature or different temperature-time values for proper pasteurization.

G.5.5

Temperature control for products requiring lower or higher temperatures than 140° F. can be accomplished by one of the following ways:

G.5.5.1

A dual diversion recorder-controller can be used to divert product at proper temperature (E.6.7.14). Such instrument must be able to be adjusted and sealed at two different diversion temperatures. The operator selects the proper diversion temperature by positioning a switch. In case of power failure, the divert point should automatically revert to the higher temperature.

G.5.5.2

Separate recorder-controllers can be used, each set and sealed to divert at the proper temperature. The separate recorder-controllers are wired to the flow-diversion valve and electrically interlocked so that only one recorder-controller operates the flow diversion valve at any one time. In case of power failure, the instrument with the higher diversion temperature shall operate the flow-diversion valve.

G.5.5.3

A multidiversion point recorder-controller can be used when a range of temperatures is required. The operator selects the proper diversion temperature for the product and the setting is continuously recorded on the control chart during pasteurization (E.6.7.14).

G.6

Stopping the Pasteurizer.

G.6.1

When the product in the raw-product constant-level tank has been drawn down to a point at which it is all drained into the outlet, the product remaining in the pasteurizer can be removed by continuously introducing potable water into the raw-product constant-level tank.

G.6.2

The flow of product from the pasteurizer should continue to the pasteurized product drawoff tank as long as the product is free from dilution. Then the bypass valve should be turned to the bypass position and the remaining product-water mixture discharged to waste. The time at which the bypass valve should be turned to the bypass position shall be determined at the time of initial operation by comparison of discharged product with infeed product by suitable laboratory procedures.

G.6.3

Shut off the main steam valve and stop flow of heating medium. Stop flow of cooling medium, and shut off the timing pump and all component units.

G.7

Cleaning Pasteurizer and Equipment.

Specific instructions for CIP (cleaning-in-place) are generally furnished by the pasteurizer equipment manufacturer and the detergent supply company. We offer a suggested procedure in section G.7.1 to G.7.9. However, it is not required that processors use these specific procedures.

G.7.1

All companents, such as the plunger of flow-diversion valve and metering pump impellers that cannot be effectively cleaned in place should be removed from the pasteurizing system for manual cleaning.

G.7.2

Temporary connecting line(s) and cleaning systems can be inserted to provide a continuous circuit for flushing and cleaning the pasteurizing system.

G.7.3

Use of the variable-speed positive metering pump to circulate cleaning solutions may cause excessive wear on its close-fitting surfaces. It is permissible to use a corrosion-resistant centrifugal pump or separate CIP system or both to circulate cleaning solutions. A 3,600 r.p.m. centrifugal pump may be used, having a capacity sufficient to give a minimum scouring velocity of 5 feet per second in the largest-size tubing in the piping system being cleaned.

G.7.4

If a three-way valve is used to bypass the flow-diversion valve, the solutions can be diverted to go from the holding tube to the flow-diversion line back to the balance tank; or the solutions can be diverted to go from the holding tube to the cooling section and then to the pasteurized liquid egg holding tank.

G.7.5

Circulate a caustic or detergent solution, and increase the temperature to that recommended by the cleanser supplier for the specific product being used. The caustic content should not exceed 1.0 percent, and the temperature should not exceed 180° F. Time needed for this circulation step will depend upon the amount of buildup on the pasteurizing plates and tubes.

G.7.6

Turn off heat source used to heat the cleaning solution. Flush this solution with tap water. Proper flushing of this solution is indicated when plates are cool.

G.7.7

If cleanup inspection determines that equipment is not properly cleaned, an acid cleaning solution circulated through the system may be required. Some plants may find that a once-a-week acid rinse is ample to avoid any buildup on the plates, while others may need to use this acid-cleaning solution daily. This acid-cleaning step should always be followed by a thorough flushing with tap water.

G.7.8

Sanitizing by either the hot-water or chlorine-solution method is required when the pasteurizer is started as detailed in sections G.2 and G.3. A chlorine sanitizing solution is recommended when the system is to be used promptly. Chlorine sanitizer solution remaining on stainless steel over 30 minutes may be injurious to the metal.

G.7.9

Balance tanks and holding tanks are cleaned by brushing of high-pressure sprays. They can be sanitized by filling with hot water or spraying with chlorine solution. Spraying the metal surface with a steam hose is ineffective. Lids and covers must be brushed or cleaned by high-pressure spray.

G.8

Inspection of Cleanup.

G.8.1

The pasteurizing plates must be separated and inspected after each run. CIP, while an efficient method of cleaning, cannot be relied upon to clean plates completely at all times.

G.8.2

Any plate with egg on it must be handbrushed with a cleaning solution.

G.8.3

One top elbow and one bottom elbow on the holding tube must be removed for inspection. The elbow and long run of pipe can then be examined. It will be necessary to use a flashlight. If the inside surface is not bright, the system is not clean.

G.8.4

Close inspection should be made of the surface of the regenerator plates for any evidence of etching or pitting. Any defective plate shall be replaced with a known sound plate.

H. DETERMINATION OF HOLDING TIMES.

H.1

Average Holding Time.

Pasteurization specifications require that every particle of product be held for a least the minimum specified time for the temperature used. If the average holding time is twice the specified time for the fastest-moving particle, it will guarantee that every particle is held at least the minimum required time. Therefore, normal control of plant operation uses average holding times (twice the fastest particle time).

H.1.1

Average holding-time determinations should be made at the start of each daily run and for each product. Additional determinations during runs may be required to meet changes in operating conditions, especially for those units that are operating at or slightly above the required holding time.

H.1.2

Operation of the pasteurizer during a determination should be the same as that anticipated for the continuing run. This includes such factors as raw-product temperatures and viscosity, heating and cooling water temperatures, pump settings, and any devices affecting pressures.

H.1.3

The flow rate (volume per unit time) can be measured in any convenient manner that is agreeable to the proper inspecting agency which has information to relate the measured flow rate with holding time for each specific holding tube arrangement. The holding capacity of tubes is obtained by multiplying the length of the tubes in feet by the amount of product per foot of length. Values for the latter will be provided by the inspection agency or they may be obtained from table 3, page 5 of this manual. By dividing the capacity of the holding tube by the average holding time (usually 3.5 minutes) the maximum permissible flow rate will be obtained. (Conversely by dividing the capacity of the holding tube by the measured flow rate, the average holding time may be obtained. Once the relation between weight and volume is known (see table 5), the flow rate can be calculated from the weight of product delivered per unit time.)

H.2

Minimum Holding Time.

H.2.1

The determination of minimum holding time (time for fastest particles) will only be required in special situations at the discretion of the proper inspecting agency.

H.2.2

Methods for making these determinations have been described in references *29* and *45*.

I. STAINLESS STEEL MATERIALS

Stainless steel conforming to the applicable composition ranges established by AISI for wrought products, or by ACI for cast products, should be considered in compliance with the requirements of section D.1 herein. Where welding is involved, the carbon content of the stainless steel should not exceed 0.08 percent. The reference cited in section D.2 sets forth the chemical ranges and limits of acceptable stainless steels of the 300 series.

Cast grades of stainless steel equivalent to types 303, 304, and 316 are designated CF-16F and CF-8, respectively. These cast grades are covered by ASTM[6] specifications A296 and A351.

J. PROTECTION AGAINST RECONTAMINATION.

The final pasteurized and cooled egg product shall be carefully protected from recontamination to insure its safety as a food product.

6/ Available from American Society for Testing and Materials, 916 Race Street, Philadelphia, Pa. 19107.

J.1

Storage and Filling Rooms

To prevent manual or airborne contamination to the pasteurized product from shell and freshly broken eggs, a separate closed room should be provided for the pasteurized-product storage tanks and the filling operation.

J.1.1

The separate storage and filling room should be supplied by a ventilating fan with clean, filtered, safe air. The air should be drawn from the cleanest convenient source in sufficient volume to maintain a slightly positive pressure in the room. Sixteen changes of air per hour and a higher air pressurization of the room of one-eighth inch water gage are suggested.

J.1.2

Filters used should have an efficiency of at least 95 percent by the National Bureau of Standards test.

J.1.3

Drainage for this room should be obtained by sloping the floor to the outside of the room to avoid a separate floor drain in this room.

J.2

Handling and filling containers. A person who fills, handles, or prepares pasteurized egg containers or storage tanks for filling should not handle the raw product, its containers, tanks or other equipment unless he changes his outer clothing and washes his hands after each contact. The person filling the containers should avoid contact with trucks, pallets, slat separators, or other possibly contaminated surfaces.

J.3

Hand-washing facilities with hot and cold water, with controls operated by other than hand, should be conveniently available.

J.4

Pasteurized product containers should be clean and sanitary. They should be handled and filled in a sanitary manner without placing the hand or fingers on inside surfaces which the pasteurized product will contact.

Single service containers shall meet the standard of not-to-exceed one colony per cubic centimeter of container content in three out of four samples and shall be free of coliform organisms, when examined by the method for rinse count outlined in the Amercian Public Health Association publication, Standard Methods for the Examination of Dairy Products *(1)*.

Multi-use containers shall have a residual bacteria count, just before use, of not more than one colony per sq. cm. (50 per 8 sq. in.) of surface area in three out of four swab samples and shall be free of coliform organisms.

J.4.1

Containers should be stored in a clean, dry area physically separated from rooms in which raw product is exposed, handled or processed. They should not be opened for filling until this can be done in the separate filling room which is supplied with clean filtered air.

J.4.2

To avoid possible airborne contamination in raw-product processing rooms, pasteurized-product open containers that are washed and effectively sterilized should be stored in the filling room or effectively covered while they are cooling and awaiting filling.

J.4.3

Prelidded metal cans, nested tapered cans supplied in plastic film-covered bundles, and straight-sided cans packaged in heavy paper bundles should be opened and temporarily held in the filling room before filling. To provide a clean commercially sterile receptacle, other containers should be similarly handled and filled under similar precautions against recontamination of the pasteurized product.

J.5

The pasteurized liquid product filler should be so designed and located that filling can be accomplished without the operator's hands (a) being splashed by or contacting the product or (b) being over the open top of the can during filling. This is accomplished best by an automatic filler but can be readily met in a hand-filling operation by adjusting the handle length and the location and relative height of the valve and top of the can being filled.

J.6

Air for drying eggs when drawn from the outside should be through an opening in the building located at least 6 feet from the roof, ledges, or walls that birds might frequent. Such air must be filtered to eliminate dust and other airborne contamination by use of filters with an efficiency of at least 95 percent by the National Bureau of Standards test. The air discharge from the drying system should be as remote from the fresh air intake as practicable.

(Note: At this printing, recent installations of

air filters, rated at an efficiency of 99.97 percent, are operating and being studied in existing egg processing and drying plants. These will help to evaluate the practicability and desirability of this air filter efficiency for egg drying.)

K. SUPPLEMENT FOR PASTEURIZATION PLANTS NOT UNDER CONTINUOUS USDA INSPECTION.

Experience in the installation and use of HTST (high-temperature short-time) pasteurizers has proved certain practices to be desirable and helpful from a sanitary control and operational standpoint. It is the purpose of this Supplement to set forth additional suggested procedures, as a guide in establishing the best practices for processors not under continuous inspection.

K.1

Application to Install.

Any egg product dealer or processor desiring to install an approved HTST pasteurizer in his plant, or any plant under his control, should first make application on a suitable form.

K.1.1.

It is suggested that the egg pasteurization inspection agency adopt an APPLICATION TO INSTALL form, including the data provided for in FORM 1. A REPORT OF INSTALLATION form, similar to FORM 2, is recommended for use in reporting the check-testing data prescribed in section F.16. (See pages 44 and 45.)

K.1.2

The manufacturer should provide the applicant with two copies of Form 1, giving necessary details and the flow diagram. Application should be submitted to the State or other appropriate inspection agency by the applicant, on suitable forms, at least 15 days before the start of any installation. Approval or advice as to necessary changes should be made to the applicant promptly.

K.1.3

Each "type" of a manufacturer's standard unit may be made available by the processor to the proper control authority, for general approval for installation in his jurisdiction at any time.

K.1.4

It is recognized that any manufacturer's so-called standard does not fit all operating conditions of all processors. Therefore, if any installation requires deviation from the standard already generally approved for use in the jurisdiction, the details of all deviations must be submitted with the initial application for installation and approval must be received by the applicant before the installation.

K.1.5

Notice of the approximate time when an installation will be ready for checking and testing by the inspection agency shall be given in writing at the time application is made, or at least 7 days before the time the unit will be ready for checking and testing by the inspection agency.

K.1.6

Changes in an existing system, affecting capacity or arrangement, should be submitted by the processor on a form as specified in Section K.1.1.

K.2

Regenerator Product Pressures.

K.2.1

The pressure on the pasteurized side of the regenerator plates shall be maintained above that on the raw side (see section E.3.2).

K.2.2

Where the use of control equipment is permitted under state or local regulations for the purpose of maintaining the regenerating pasteurized product under greater pressure than the regenerating raw product, the use of a *raw product booster pump* is acceptable at a location between the outlet of the raw product constant-level tank and the inlet to the raw side of the regenerative section.

K.2.3

This raw product booster shall be permanently wired so that it cannot operate unless—

K.2.3.1

The timing pump is in operation.

K.2.3.2

The flow diversion valve is in forward flow position.

K.2.4

The motor, casing, and impeller of the booster pump shall be indentified, and such records thereof maintained as directed by the inspection agency.

K.2.5

The raw product booster pump shall be selected as to capacity and head pressure so that, when the pasteurizer is in any stage of operation, the pressure in the raw product passages in the regenerative section shall at all times be lower than the pressure in the pasteurized product passages in the regenerative section.

K.2.5.1

An automatic control device shall be provided that will not allow the raw product booster pump to operate unless the pressure at the pasteurized product outlet of the regenerator is a least 1 pound per square inch higher than the pressure at the raw product outlet of the regenerator.

K.3

Holding Time Control or Recording.

K.3.1

If different holding time requirements are necessary, the electrical switch that selects the diversion temperature (in the case of a dual diversion instrument) or the recorder-controller (in the case of multiple instruments) also supplies power to the circuit governing the speed of the flow-promoting device (timing pump), which determines the minimum holding time. Such speed control circuits may be two speed or electrical interlocks that can be present at specific values on variable-rate flow-promoting devices.

K.3.2

To record the speed and capacity of the timing pump, a recording tachometer may be used. This consists of a tachometer generator attached to the end of the intermediate shaft of the variable-capacity drive on the pump. The low voltage current generated is directly proportional to the speed of the pump and is recorded on a strip recorder chart calibrated in revolutions per minute, which can be convered to pounds per hour flow rate of egg product. On some instrument arrangements it is possible to use the temperature recording chart to register the current from the tachometer. These values are calibrated to pumping rates.

APPENDIX 2

REFERENCES TO 3-A SANITARY STANDARDS AND ACCEPTED PRACTICES

(Reprints can be purchased from the *Journal of Milk and Food Technology,* Box 437, Shelbyville, Indiana)

1. 3-A Sanitary Standards for Storage Tanks for Milk and Milk Products, Serial No. 0101 as amended.
2. 3-A Sanitary Standards for Pumps for Milk and Milk Products, Revised, Serial No. 0203, as amended.
3. 3-A Sanitary Standards Covering Homogenizers and High Pressure Pumps of the Plunger Type, Serial No. 0400 as amended.
4. 3-A Sanitary Standards for Fittings Used on Milk and Milk Products Equipment and Used on Sanitary Lines Conducting Milk and Milk Products, Serial No. 0800 as amended, and Supplements thereto.
5. 3-A Sanitary Standards for Thermometer Fittings and Connections Used on Milk and Milk Products Equipment, Serial No. 0900 as amended, and Supplement thereto.
6. 3-A Sanitary Standards of Plate Type Heat Exchangers for Milk and Milk Products, Serial No. 1100 as amended.
7. 3-A Sanitary Standards for Internal Return Tubular Heat Exchangers for Use with Milk and Milk Products, Serial No. 1200 as amended.
8. 3-A Sanitary Standards for Farm Milk Cooling and Holding Tanks (Revised), Serial No. 1301 as amended.
9. 3-A Sanitary Standards for Multiple-Use Rubber and Rubber-Like Materials Used as Product Contact Surfaces in Dairy Equipment, Serial No. 1800.
10. 3-A Sanitary Standards for Multiple-use Plastic Materials Used as Product Contact Surfaces for Dairy Equipment, Serial No. 2000.
11. 3-A Sanitary Standards for Non-Coil Type Batch Processors for Milk and Milk Products, Serial No. 2500.
12. 3-A Accepted Practices for Permanently Installed Sanitary Product-Pipelines and Cleaning Systems, effective June 9, 1966, as amended.
13. 3-A Accepted Practices for the Sanitary Construction, Installation, Testing, and Operation of High-Temperature Short-Time Pasteurizers, Revised. Published January 1967, by International Association of Milk and Food Sanitarians, Inc.

Form 1

INFORMATION TO BE FURNISHED BY APPLICANT, WITH APPLICATION FOR PERMISSION TO INSTALL A HIGH-TEMPERATURE SHORT-TIME PASTEURIZER

Name and address of egg processor ....

Jobber ....Manufacturer ....

Capacity (lb. per hr.) ....

Approximate date of installation ....

Plates:

		Number
Product regenerator	Plates	....
Product heater	Plates	....
Product cooler	Plates	....

	Make	Model
Timing pump	....	....
Timing pump drive	....	....
Flow-diversion valve	....	....
Recorder-controller	....	....

Holding tube — diameter of largest cross section ....

Additional equipment: Give make, model, size, and safety controls of each piece of additional equipment that is to be connected to the pasteurizer.

	Make	Model	Capacity
Auxiliary pump (if any)	....	....	....
High pressure pump	....	....	....

Other remarks: ....

....

Signed ....
(Seller)

By ....

Date ....

Form 2

REPORT OF INSTALLATION — HTST PASTEURIZERS

(Information to be Furnished USDA and Plant Operator
by HTST Manufacturer's or Processor's Qualified Representative
on Completion of Installation)

Name of egg processor and address ....

Manufacturer .... Jobber ....

Nominal capacity (lb. per hr.) .... Serial No. ....

I. CONTROL INSTRUMENTS

A. Indicating thermometer (hot product)

Make .... Serial No. ....Accuracy .... F Lag .... Seconds

B. HTST recorder controller

Make .... Serial No. .... Accuracy ± .... F

Cut-in point .... F Cut-out point .... F

Thermometric lag .... Seconds

Flow-diversion valve:
1. Response time in seconds ....
2. Does flow leak past forward flow seat when operating in diversion with forward-flow line disconnected? YES .... NO ....
3. Does valve seat properly? YES .... NO ....
4. Do leak escapes open properly? YES .... NO ....
5. Does timing pump stop when valve fails to seat properly? YES .... NO ....

II. TIMING PUMP

A. Pump head

Make .... Serial No. .... RPM at maximum capacity setting ....

Rate of flow (lb. per hr.) at max. rated capacity ....

B. Variable speed drive

Make .... Serial No. ....

Range of rated capacity (lb. per hr.) High .... Low ....

III. Check test to determine the volume of product required to displace water at startup and time to discharge product and shutdown. These checks are to be carried out in accordance with section H.1.3 (for volume) and section H.1.1 (for time) of Appendix 1, "USDA Accepted Practices for the Sanitary Construction, Installation, Testing and Operation of High-Temperature-Short-Time (HTST) Liquid Egg Pasteurizers."

A. Startup volume ...., startup time ....

B. Shutdown volume ...., shutdown time ....

IV. Holding time information for various products is to be supplied as required (methods are described in Appendix 1, section H).

Signed: .... Date: ....

Qualified Representative of Manufacturer or Processor

I have examined the above data and tested the HTST pasteurizer and approve the HTST pasteurizer for the pasteurization of liquid egg and egg products.

Signed: .... Date: ....

Pasteurizer Inspector

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